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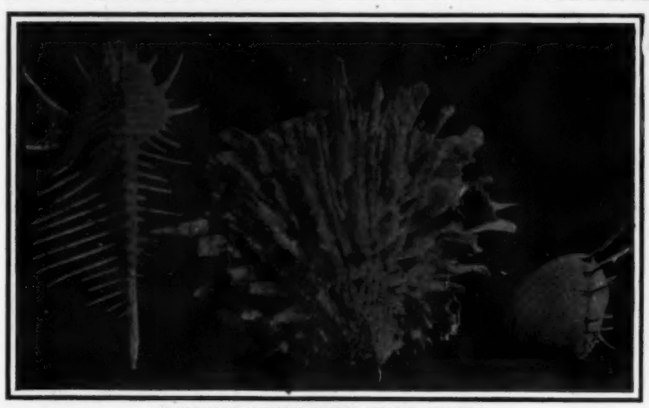
QUILLED ANIMALS.

MANY animals are protected from the attacks of their natural enemies by quills or spines, distributed over the surface of the body. The hedgehog (*Erinaeus europaeus*) is a familiar example. The back of the hedgehog is thickly beset with sharp quills, about an inch long, which in shape resemble stout pins, bent sharply near the head and gently curved throughout. The head of the quill is buried in the skin of the animal and is provided with muscular attachments by means of which the quill, which in ordinary circumstances lies flat, with its point directed backward, can in moments of danger be erected so that it stands out stiffly from the body. At such times the hedgehog usually rolls itself into a ball and thus protects the under surface of its body, which is not provided with quills. In the same posture the hedgehog can drop to the ground from a height of ten or fifteen feet without injury, owing to the elasticity of its quills.

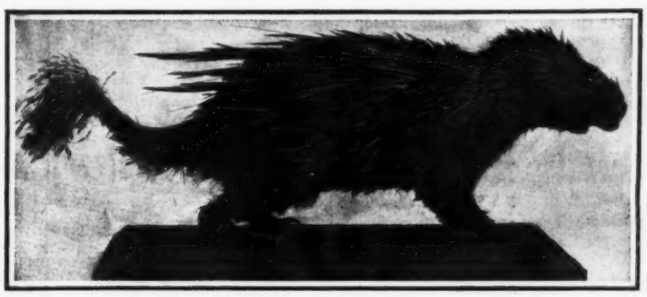


MOLLUSKS ARMED WITH SHARP SPINES.

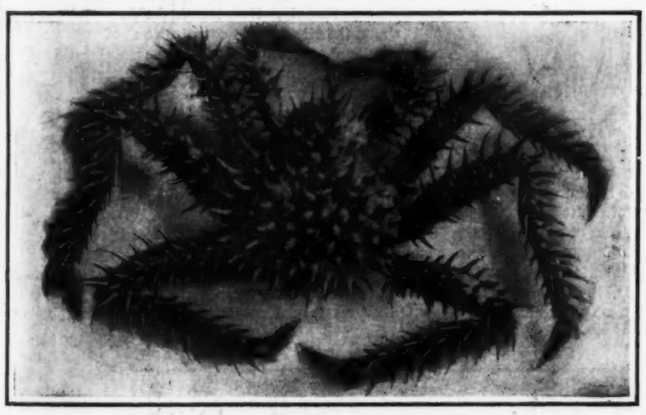
Thorny woodcock or Venus's comb. (Murex tenuispina.) Spondilus pictorum. Venus mussel. (Dione multispinosa.)

The porcupines are nearly related to the hedgehogs. They are, in general, tropical animals, but one species is found in Canada. The common porcupine (*Hystrix cristata*) furnishes the beautiful variegated quills which are so largely used as ornaments. According to popular belief these quills are very formidable weapons and the porcupine possesses the power to project them, like javelins, to a great distance, but they are really quite harmless and of little use, even for defense, as they are soft and flexible. Their chief function is to give the animal, when they are erected, a formidable appearance and to produce a rattling sound which dismays

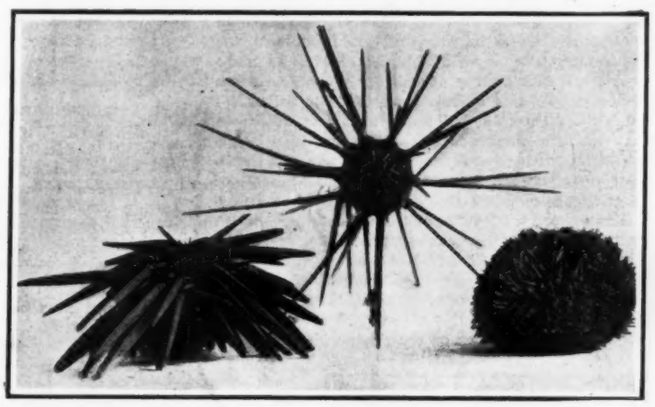
PORCUPINE ANTEATER (ECHIDNA ACULCATA).



TUFTED TAIL PORCUPINE (ATHERURA AFRICANA).

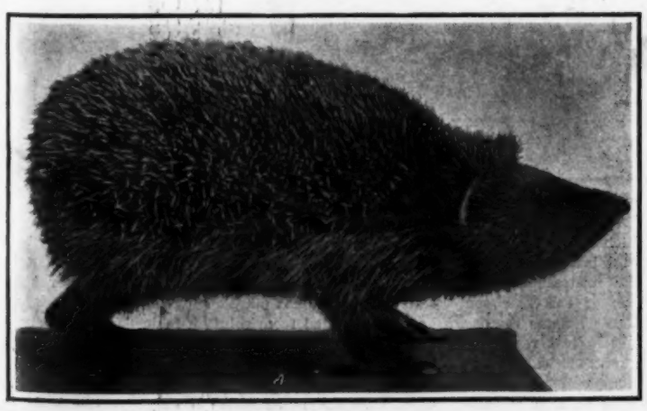


ANTARCTIC STONE CRAB (LITHODUS ANTARCTICA).

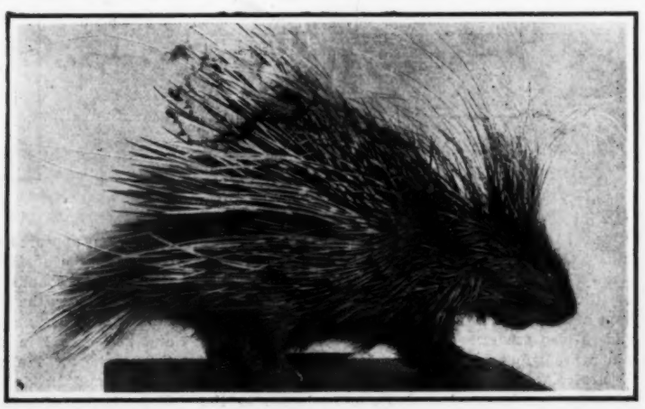


SEA URCHINS.

Heterocentratus. Dorocidaris. Echinus esculentus.



HEDGEHOG (ERINAEUS EUROPAEUS).

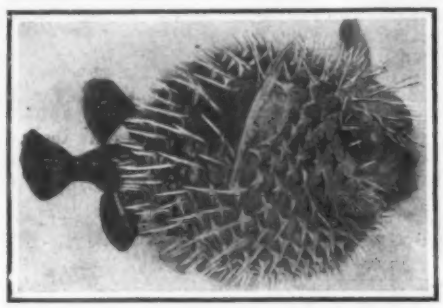


PORCUPINE (HYSTRIX CRISTATA).

QUILLED ANIMALS.

the enemy. These long quills, however, conceal shorter, sharper, and stiffer ones, which inflict severe wounds in which they remain sticking persistently, for they are easily detached from the skin of the porcupine. Some other porcupines have short sharp quills concealed by long hair. The tufted-tail porcupine (*Atherura africana*) is a comical looking member of the family.

The porcupine ant-eater (*Echidna*) belongs to a much lower, in fact the lowest order of mammals, the



PRICKLY GLOBE FISH (DIODON HYSTRIX).

monotremata, which includes only one other animal, the curious duck-bill or platypus. Both are natives of Australia, the land of strange and primitive forms of animal life. The echidna possesses, instead of a true mouth and teeth, a pointed bill and a long tongue with which it captures the insects on which it feeds. Like the hedgehog, it rolls itself into a ball when attacked and presents its short, sharp quills to the enemy.

This completes the list of quilled mammals, but the protection afforded by sharp spines is common among lower animals. The African ring-tailed lizard (*Zonurus giganteus*) is well provided with such weapons, and an Australian lizard, the moloch, is so thickly covered with them that it is an awe-inspiring object, in spite of its small size. Many other living reptiles are similarly protected and some of the colossal extinct saurians were armed with bayonets more than a yard in length. The rays or ribs of the fins of most fishes terminate in sharp points and many fishes possess additional sharp spines, arranged in a row along the back or even distributed over the entire surface of the body. The small and pugnacious stickleback is the most familiar example, but the red fire-fish and the prickly globe-fish or urchin fish (*Diodon hystrix*) are far more formidably armed. The last named fish, when alarmed, inflates itself like a balloon.

Many crabs are well provided with sharp spines. The Antarctic stone crab is thickly covered with them and must be handled with the greatest caution, even when dead. An entire order of marine animals, the Echinodermata or "prickly skins," derives its name from the bristling array of sharp points which covers the body. To this order belong the star fishes and the sea urchins. The edible sea urchin of the North Sea (*Echinus esculentus*) closely resembles a hedgehog in the attitude of defense, the Persian cap (*Dorocidarius*) of the Mediterranean has a small number of very long spines, and the *Heterocentratus* of Mauritius is covered with thick and blunt processes, which resemble clubs rather than daggers. The needle-like spines of the Persian cap break off in the wounds they make and cause severe inflammation, and the spines of some other species exude a poisonous secretion.

Spines are found even on the thick calcareous shells

THE MOUTH OF A SHARK.

of some snails and mussels, where they appear scarcely necessary for defense.

In insects, spines and stings are of common occurrence. In this connection a remarkable example of protective mimicry is exhibited by a South American beetle (*Umbonia spinosa*), which, as the accompanying illustration shows, can hardly be distinguished from a thorn of the shrub on which it feeds. Some spiders also are armed with sharp spines, which attain a prodigious length in the Javanese species here illustrated.

The poison fangs of snakes are analogous to the stings of bees and wasps. Indeed, there is good reason for believing that the whole dental apparatus of animals has been developed out of protective spines, which originally were distributed over the external surface of the body but were ultimately confined chiefly to the mouth cavity where, transformed into teeth of various sorts, they serve alike for attack, defense, and mastication. This view is confirmed by a glance at the photograph of the jaws and dagger-like teeth of the shark, which is one of the oldest of living vertebrates.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from Illustrirte Zeitung.

THE CRYSTALLINE STRUCTURE OF IRON AT HIGH TEMPERATURES.

W. ROSENHAIN and J. C. W. Humfrey have studied the crystalline structure of iron at high temperatures. They have carried out some preliminary experiments with a view to studying the modes of deformation of metals at high temperatures, on a commercially pure iron (transformer sheet) containing less than 0.25 per cent total impurities. Oxygen was removed by heating the metal in pure hydrogen at 900 deg. C. Derived differential curves showed arrests on heating, at 770 deg. and 940 deg. C., and on cooling, at 904 deg. and 763 deg. C. By means of a specially designed apparatus it was possible electrically to heat polished specimens *in vacuo*, and, when at the desired temperature, to strain them by means of a coiled spring. The temperature, which varied considerably along the specimen, being low at the ends and high in the center, was indicated by the fusion of minute particles of various salts placed on the back of the specimen. Microscopic observations were made on specimens which had been heated without and with

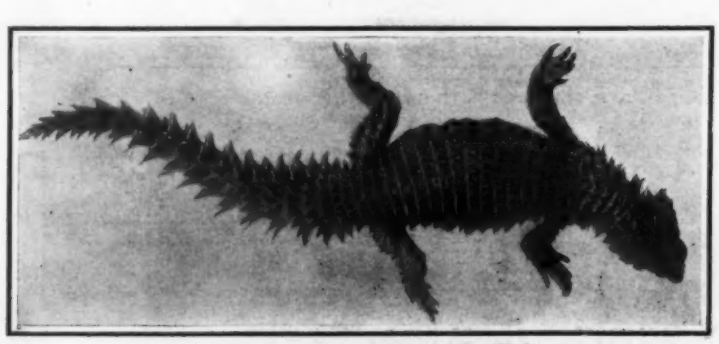
THORN BEETLE (UMBONIA SPINOSA).

straining. Unstrained specimens showed, in the central hottest portions, superposed upon the regular ferrite structure more regular and larger crystals exhibiting well-defined twinning similar to the γ-iron structure observed in Ni-steels. The strained specimens showed at the cold ends an unaltered surface, but as the temperature increased the ferrite crystals were cross-hatched with slip bands, increasing in intensity until at a certain point a sharp line of demarkation appeared, beyond which the slip bands cease and the surface of the metal becomes covered with double boundaries as in the unstrained specimens. Nearer the hottest portion of the specimen minute slip bands were found. These became regular and well-defined in the center and hottest region of the specimen. Since metals without critical points, like Cu and Pt, do not show this phenomenon, the discontinuity of surface in the case of iron is associated with the existence of the three allotropic modifications α, β, and γ in the various temperature-ranges, the sharp line of demarkation making the α/β change. When the stress was high enough to break the specimen, fracture always occurred on the colder side of this line and not in the region of the highest temperature as observed in the cases of Cu and Pt. The results indicate that as the temperature increases α-iron becomes weaker and shows an increased tendency to slip. As a result of α/β change an increase of tenacity occurs in spite of the weakening effect of heating, and the absence of slip bands proves that the material has been hardened by the transition. The truly crystalline nature of γ-iron is indicated by

A JAVANESE SPIDER.

THE STING OF A BEE.

the slip bands tending to follow the steps of the twin crystals. The authors conclude that up to 1,100 deg. C. iron behaves as a crystalline aggregate, undergoing plastic deformation by a process of slip on the cleavage planes of the crystals, which may or may not be accompanied by mechanical twinning. Iron exists in three modifications possessing widely different mechanical properties, the temperature-ranges in which they exist being consistent with the view of their identity with the α, β, and γ forms of Osmond and Roberts-Austen. Although it exists at a higher temperature, β-iron is both harder and stronger than α-iron. The γ-iron existing in pure iron at high temperatures is similar in structure and properties to the γ-iron of alloy steels.—Roy. Soc. Proc.



RING TAILED LIZARD (ZONURUS GIGANTRUS.

SYNTHETIC RUBBER.

IN statements recently made by Klages and by Harries, certain doubts have been expressed regarding the possibility of the polymerization of isoprene into caoutchouc by the methods indicated by Tilden. These methods were of two characters, (1) the action of certain reagents (for example, an aqueous solution of hydrogen chloride) on isoprene, and (2) the slow spontaneous polymerization of isoprene itself. The latter method was repeated by S. S. Pickles, and a white, rubber-like compound was produced, which gave derivatives like those obtained from natural caoutchouc, namely, the tetrabromide $(C_{10}H_{16}Br_4)x$, and the nitrosite. The constitution of caoutchouc was discussed, objection being taken to the dimethylcyclooctadiene formula. Other formulæ were proposed for caoutchouc, and the ozonide which, Mr. Pickles considered, afford a better explanation of the properties and behavior of these substances. Kondakoff had shown that methylisoprene ($\beta\gamma$-dimethyl-$\triangle^{\alpha}$-butadiene) underwent polymerization to a rubber-like compound in a few months' time. Mr. Pickles himself made the experiment with dimethylisoprene ($\beta\delta$-dimethyl-$\triangle^{\beta\delta}$-pentadiene), but this did not appear to polymerize readily. The displacement of the hydrogen atoms attached to the terminal carbon atoms of isoprene by methyl groups apparently prevented or restrained polymerization. The polymeride of isoprene, as at first precipitated, was more or less sticky. This was probably due, not to resin, but to the presence of hydrocarbons other than rubber. Natural rubber was similarly sticky and weak, when first precipitated from solution in terpenes. Although Harries had obtained a rubber-like compound from the polymerization of octadienes, he had not shown that it formed additive compounds of the type, $C_{10}H_{16}Br_4$. Ethyl acrylate readily polymerized to rubber-like compounds, but in the process the double bond disappeared.—Chem. Soc. Proc.

THE INDIA-RUBBER INDUSTRY.—II.

PAST, PRESENT, AND FUTURE.

BY PHILIP SCHIDROWITZ, PH.D.

Concluded from Supplement No. 1801, page 27.

Chemistry of Crude Rubber, and the Question of "Synthesis."—According to the classical work of Harries,* India rubber is a ring compound, namely:

$$CH_2.C.\ CH_2\ CH_2.CH$$
$$CH.CH_2.CH_2.C.CH_2$$

that is a polymer of 1.5 dimethyl-*cyclo*-octadiene.

I have already referred to the fact that according to the work of Harries,† this polymer exists in at least two isomeric modifications. Although there is no apparent flaw in the chain of Harries's chemical reasoning, one is face to face with the fact that India rubber has on several occasions been synthesized from isoprene by observers whose work must be regarded as beyond doubt.‡ The synthesis by Euler§ of isoprene makes it apparently certain that this compound possesses the structure:

$$CH_2 : C(CH_3).CH : CH_2.$$

To reconcile Harries's, Euler's, Tilden's, and Bouchardat's work it is necessary to assume that the open-chain compound isoprene in polymerizing forms a ring compound, and that at the same time a somewhat unusual intramolecular rearrangement of linkages takes place. At the present time there appear to me to be two main lines of work which are worth following up in this connection, first the synthesis from isoprene, and secondly that from laevulinic acid or its derivatives.‖ If, as is anticipated, rubber can be obtained ultimately, in practically unlimited quantities, from the plantations and other sources at 1s. to 1s. 6d. per pound, no synthetic process which works at any appreciably higher figure is likely, in the long run, to prove a commercial success. Briefly put, the chemist must be able to produce rubber at something like 1s., otherwise the synthetic product cannot come to stay; such a price does not leave a great margin in the choice of raw material or cost of production. Synthetic indigo is frequently mentioned in discussions of the synthetic rubber problem, but the comparison is misleading from every point of view, but mainly because the lowest price at which natural indigo can be prepared is relatively speaking a very high one. With regard to the synthesis from isoprene, the problem appears to be the production of this substance at a very low cost, for it appears to be not unlikely that a satisfactory conversion of isoprene into rubber will ultimately be achieved. Another factor which may complicate the scientific problem is that it is necessary to produce not only a definite chemical substance, but that, in addition, this substance should have certain definite physical properties. It is, however, possible that these problems may be found to overlap. The differences in regard to mechanical strength which certainly exist as between different species and also as between rubbers of the same species prepared in different ways or derived from different localities, both in the case of the crude and the vulcanized articles, have not yet found a satisfactory explanation. In this direction a great deal of useful work may well be done.

The Manufacture of Rubber Goods.

The main processes employed in the manufacture of articles from crude rubber are still largely empirical, partly because the industry is comparatively young and partly because the principles governing manufacture are by no means clearly defined.

The India rubber article in the process of manufacture is subjected to a series of operations which are briefly as follows: First, the crude rubber as it arrives at the factory must be purified, and this is done by the process called washing. The washed rubber is subsequently dried. If ordinary "mechanical" goods are to be made, the next process is that of mixing. This consists in incorporating with the rubber the necessary quantity of sulphur and filling materials. The next step as a rule is that of calendering; this consists in rolling out the well-mixed and homogeneous dough to sheets of the required thickness. The calendered material passes next to the making-up table where it is cut to suitable sizes either for the hydraulic vulcanizing press or prepared for the molds. The next process is that of vulcanizing which consists substantially in subjecting the calendered dough to combined heat and pressure, or heat only, in the press, in a mold, or in the open. In the case of many solid tires the rubber is not first calendered, but the well-mixed dough is forced through an appropriate die. The same applies to squirted tubing. In the case of elastic thread the rubber is mixed with flowers of sulphur and "let down" with a solvent, and the mass so obtained spread or calendered on to the cloth. The above remarks refer to goods which are made by the hot process of vulcanization. There is, however, a large class, such as articles made from cut sheet, waterproof goods, and broadly speaking, all articles in which the rubber layer is very thin, which is prepared by the cold process. In this method the rubber is not first mixed with sulphur and then exposed to heat; but is subjected in the form of a thin layer or sheet to the action of a dilute solution of sulphur chloride in a suitable solvent or to the action of sulphur chloride vapors. The cold process cannot be applied to goods of any thickness because the action of sulphur chloride is so powerful that by the time the interior of a piece of rubber of any thickness is properly cured, the outer portions are over vulcanized.

The ordinary process of washing consists in passing the rubber, after it has been cut up and soaked in warm water to render it pliable, through corrugated, fluted or diamond-cut rolls working at uneven speeds, and at the same time subjecting the mass to the action of a stream of water. By this process dirt, sand, bark, etc., are forced out of the rubber, which is obtained in the form of a corrugated sheet of crêpe-like texture. It is probable that at no very distant date the process of washing, which involves the use of much power and time, and apart from its actual cleaning effect, is certainly not beneficial to the rubber, will be abandoned. It is now well recognized that the less rubber is subjected to mechanical action the better, for the more it is worked the softer and less resilient it becomes. At the present day much of the clean plantation rubber is not washed, but is taken to the mixing rolls after a short preliminary drying. There is no object in washing rubber which is dry and clean and which contains substantially no soluble matter.

Drying.—After the rubber has been washed it must be thoroughly dried, either in well-ventilated chambers or in a vacuum dryer; occasionally nowadays the last trace of moisture is removed by passing the goods through hot rolls.

Mixing.—The ordinary mixing rolls are of much the same type as the rolls used on the washing machine, except that they are smooth, and run dry. The rolls are hollow and are heated by means of steam or cooled with water. When the rubber has been reduced to a plastic condition on the mixing rolls, the sulphur and other materials which are to be incorporated are then gradually added. Although many attempts have been made to replace the apparently crude method of mixing by a more scientific process, all such attempts, so far as I am aware, have failed. If the rubber is made into a thin paste with a solvent, there is the cost of the latter and also its removal. Also rubber which has been treated with a solvent always appears to lose strength very badly. It is now generally recognized that the less the rubber is worked with the solvent the stronger the solution will be. The question of the mechanical working of rubber is one which is well worth exhaustive investigation; if means were found to avoid the mechanical working of the mixing process, a very great step forward would be gained. Mr. Kelway Bamber proposes to incorporate the sulphur and other matters with the latex or during the process of coagulation, thus avoiding all mechanical working.

Calendering and Spreading.—The primary object of calendering is to transform the rubber dough into sheet form. From this sheet various articles are built up prior to vulcanizing. The calender is, however, used for other purposes; for instance, to replace the old spreading machine. The spreading machine is a long iron steam chest which is fitted at one end with a horizontal roller above which there is an adjustable iron gage. The cloth which is to be treated passes between the roller and the gage, a thin layer of paste (made of rubber and solvent) regulated by the gage, being applied to the cloth during its passage. The cloth then passes along the steam chest which serves to evaporate the solvent. Hoods communicating with refrigerating plants are frequently fitted for the recovery of the solvent. Of late years the tendency has been more and more to replace this process of spreading by calendering, a special type of calender being used. The advantage of the calender over the spread is that there is a great saving in regard to solvent, but there is some difficulty in getting an even proofing, particularly when this is to be very thin.

Vulcanizing.—The vulcanization of rubber goods must remain more or less empirical, in spite of the work of Weber, and later of Axelrod, Hinrichsen, etc. Axelrod has recently suggested that there are two main factors in hot vulcanization, namely, the entry of sulphur into the rubber molecule, and a change of the state of polymerization of the molecule. These factors in a sense work in opposite directions, and attain certain maxima under definite conditions of time and temperature. The term "polymerization," or "depolymerization" of rubber* should be used with some caution, for it is probable that some of the physical effects observed are due not to any change in molecular complexity, but merely to modifications in the colloidal aggregate.

The hot vulcanizing process is applied more rarely nowadays by means of live steam; the majority of goods are now cured either in a steam-jacketed or ordinary hot-air chamber, or in the vulcanizing press. Molded articles, which were formerly vulcanized in live steam or in hot air, are now more generally vulcanized in a mold press. It is becoming recognized that pressure is a factor which is only of secondary importance to time and temperature in the vulcanizing process, particularly where goods of any strength are required. Another tendency which is noticeable is that of replacing, particularly in the case of waterproofed goods, the cold by the hot process. Formerly waterproofed goods were invariably made by "frictioning" a thin layer of rubber on to the cloth by means of the calender or spreader, and then passing the cloth with its rubber layer through a trough containing a dilute solution of sulphur chloride in carbon bisulphide. This process requires very great care. Nowadays it has in many works, except for special classes of goods (i. e., those which will not stand heat), been replaced by hot vulcanization. A well-mixed dough of rubber and sulphur, and such other materials as are desired are frictioned on to the cloth, and this is then slowly drawn through a series of rolls in a hot-air chamber, the time being so regulated as to obtain perfect vulcanization.

Substitutes and Residuals.

"Substitutes."—Although in the proper sense of the term no substitute for India rubber exists, there is a class of substances which is known in the industry as "substitutes," produced by vulcanizing vegetable oils such as colza, rape, maize, and cotton-seed oils, either in the cold with sulphur chloride or hot with sulphur. Substitutes produced by the cold process are generally known as white substitute, those by the hot process as brown or French substitute. They have been produced on a considerable scale for certainly forty years, and a goodly number of patents has been taken out in connection with their manufacture. As the price of these substitutes varies from about 3½d. to 9d. per pound, their use effects a considerable saving in the cost of the rubber article in which they are incorporated. They are employed in order to cheapen the cost of production and where the goods to be produced are to be of low specific gravity. The advantage of the substitute over mineral fillers is that the plasticity of the mixing is not affected to any extent, although the strength, wearing qualities, and elasticity are naturally much influenced. White substitute (which is the more expensive) is generally employed only for cold-cured goods, but the brown may be employed for either. Many other substitutes have been suggested and some are used on a considerable scale, particularly in cable mixings. Gums, bitumen, vulcanized bitumen, nitrated oils, nitrated celluloses, ceresin, etc., all find their sphere of utility in cable mixings, in insulating materials, valve rings, and so on, but a true rubber substitute has yet to make its appearance.

Residuals.—An enormous quantity of waste rubber finds its way into the market. If we assume that the crude rubber employed in the manufacture of goods in the British market yearly amounts to 12,000 tons, and that this re-appears in the shape of finished rubber articles containing on the average perhaps not more than 30 per cent of rubber, it is plain that there

* C. Harries and others. Ber., 1904, 2708; *ibid.*, 1905. 1195, etc.

† C. Harries and others, Ber., 1905, 3985, and Gummi-Zeit, 22, 12, 305.

‡ Cf. Tilden. Birmingham Phil. Soc., May, 1892; do. *India, Rubber J.*, 1908, p. 321, and Bouchardat, Comptes Rend., 1879, 1117.

§ Ber., 1897, pp. 1989 et seq. and Habilitations-schift, Leipzig, 1897.

‖ By splitting rubber ozonides Harries obtained laevulinic acid and laevulinic aldehyde.

* Cf. Spence. *India-Rubber J.*, Q. Cent. No. p. 46.

must be something like 30,000 to 40,000 tons of waste rubber annually. The waste rubber industry is an important one in itself and a special organization exists for the collection of this material. Broadly speaking, waste rubber is utilized in one of three ways: (*a*) It is ground up (where the article permits of such simple treatment) and used direct in the ground state by the rubber manufacturer in his mixings for the cheaper varieties of goods; (*b*) it is subjected to one of the reclaiming processes which substantially consists in freeing the rubber from fiber, dirt, and particles of metal, and subsequently removing as much as possible of the free sulphur and non-rubber substances; and (*c*) the rubber is submitted to a re-forming process, by *re-forming* being understood a process which employs substantially only heat and pressure.

Reclaimed Rubber.—In the old reclaiming processes the rubber was ground, the metal particles and vegetable fiber removed, and the mass then heated together with mineral oil and subsequently rolled out into homogeneous sheets. By this process no sulphur was removed. The newer processes all involve wet treatment and the removal of sulphur. Some of the reclaimed rubbers so made are of remarkably good quality; indeed, the better varieties, which are made from the best qualities of scrap, fetch appreciably higher prices than some of the inferior crude rubbers. In the oldest of the wet processes fiber is destroyed by means of sulphuric or hydrochloric acid, part of the mineral matter also being removed; the process is chiefly suitable for lightly cured scrap such as that from proofed goods, as very little sulphur is removed.

In the alkali process, which is the one most generally adopted by large works in the United States and the United Kingdom, the scrap is first sorted, ground, metallic particles removed by magnetic separation, the ground rubber shaven in perforated trays to get it in an evenly divided state, and subsequently heated under pressure in iron vessels with alkali, washed, and sheeted. It is claimed that in this way the whole of the free sulphur is removed. Another process is that in which neutral sulphites are employed for the removal of sulphur. A number of reclaiming processes have been proposed (some of which are, I think, working) in which, after mechanical cleaning, the whole rubber mass is dissolved in a suitable solvent; these solvents are generally of a neutral character and of high boiling points (petroleum, terpineol, etc.). From the solution so obtained the rubber is precipitated by means of a non-rubber solvent such as alcohol. I have not personally come across any reclaimed rubber which does not still contain a very considerable proportion of sulphur.

Re-formed Rubber.—During the past few years a number of patents has been taken out by Gare, Immisch, and others, for processes which effect the direct production of molded articles from ground or flaked scrap mainly by means of heat and pressure. Exceedingly good results are obtained in this way, and it is remarkable that this simple method of dealing with "mechanical" scrap was not discovered at an earlier date. The fact remains, however, that particles of vulcanized rubber in the shape of dust or flakes can be molded by pressure and heat to a homogeneous mass, which on cooling, is to all intents and purposes indistinguishable from an ordinary molded article.

THE PLACE DE L'OPERA STATION.

A COMPLEX ENGINEERING FEAT ON THE PARIS METROPOLITAN.

BY LUCIEN FOURNIER.

Of all parts of Paris, the Place de l'Opera has suffered longest from the work of constructing the subway system of the Metropolitan Railway. The newspapers continually protest against the slowness of the work at this point of congested traffic, but the contractor may plead, in extenuation, the great difficulty and complexity of his task. Three lines cross at this point, at different levels, and require three stations, with means of access and communicating galleries by which passengers may pass from one station to another. The stations are very near each other and the difficulty and slowness of construction has been vastly increased by the fact that almost the entire work has been done by tunneling, the surface of the street being broken only by a single working shaft, the shafts of the two elevators, and an opening over the new entrance and ticket office.

THE TRIPLE SUBWAY STATION AT THE PLACE DE L'OPÉRA, IN PARIS.

The three lines of railway meet at a common point, near the center of the plaza. Line No. 3, which occupies the highest level, crosses line No. 7 on a steel bridge, and line No. 7 crosses line No. 8 in the same manner. Hence, as the roadway is carried over line No. 3 on a steel bridge, there are three superposed steel bridges at this point. This work and the station for line No. 3 were completed several years ago. The subsequent operations have included the construction of the stations for the other lines, a great waiting room which communicates with each of the three stations, a second stairway for entrance and exit, and a complex system of passages and steps, connecting the six platforms of the three stations with the common waiting room and with each other. The various levels of the subterranean structure are also connected with each other, but not with the street, by two elevators.

The great waiting room is 100 feet long and 23 feet wide; its floor is about 30 feet below the street level. In addition to the corridors and stairs which lead from this room to the six platforms, the two elevators and the two entrances and ticket offices, there are several independent passages which establish direct communication between various parts of the structure.

This labyrinth of passages will not be difficult to thread, for a passenger who has gone astray will always find it easy to return to the general waiting room, but the work of construction has been made very difficult by the restricted space and the intricacy of the system, and especially by the necessity of working from a single shaft, through which all the materials were brought in and all the excavated earth was removed. This shaft is situated at one end of the excavation and is surmounted by an electric crane. The openings over the elevator shafts are used only for the construction of those shafts and will be closed when the work is finished. The construction of the new ticket office over line No. 7 necessitated still another opening of the street, as the pavement rests directly on the steel roof of this room. This roof is supported by columns resting on the arch of the tunnel, which has been reinforced at this point.

All of the masonry construction is in slag cement concrete or sandstone and cement mortar. The soil to a depth of 33 feet below the street consists of alluvial sand, which rests on a bed of Beauchamp sand containing seams of sandstone. In ordinary weather conditions this lower stratum is saturated by the ground water, which is usually encountered at a depth of 36 feet below the street. Hence the platforms of line No. 8, the lower corridors and the bottoms of the elevator shafts are below the water level, but they have been constructed in a manner which makes the entrance of water impossible.

The total height of the elevator shafts is 62 feet. The shafts are 16½ feet square and each accommodates two cars, one of which rises while the other descends. The rails of line No. 8 are 51½ feet, those of line No. 7 are 35 feet, and those of line No. 3 are 20½ feet below the street level. There are 375 steps in the various flights.

Let us follow through this underground labyrinth the course of a passenger who arrives on line No. 3 (the highest level) from the Place Villiers (to the left of the drawing) and desires to transfer to a train on line No. 7 (the intermediate level) which will take him to the Place du Danube (to the top or back of the drawing). Disembarking at platform *A*, he descends the steps *B* and traverses the entire length of the general waiting room (Salle d'Intercommunication) which crosses line No. 8. He then walks through the corridor *C*, ascends the steps *D*, crosses over the line No. 7 and descends the steps *E* to the platform where he finds the train he desires to take. Most of the transfers are easier and simpler than this. If the drawing is examined attentively it will be seen that the general waiting room is connected with the platforms of line No. 3 by the steps *B* and *F*, with those of line No. 8 by the steps *G* and *H*, with one platform of line No. 7 by the steps *D* and *E*, and with the other platform of line No. 7 by the corridor *C*. Short passages at the ends of the room lead to the two elevators, while the two ticket offices and entrances are reached by the steps *F* and *I*.

It is expected that this great engineering work will soon be completed and the Place de l'Opera will resume its former appearance, with nothing but the two entrances to indicate the existence of the intricate labyrinth below.—La Nature.

In a paper before the Western Canada Railway Club, Mr. H. H. Vaughan drew attention to one of the causes of loss of economy in boilers when pressed. The boiler referred to was that belonging to a locomotive tested at the St. Louis Exhibition in 1904. The tests showed that the principal cause of inefficiency at high duties in a locomotive boiler was loss of fuel unburnt. In the particular case referred to about 5 per cent of the fuel was lost unburnt when the fuel burnt amounted to 25 pounds per square foot of grate area per hour. This loss increased regularly with an increase in the rate of combustion until it amounted to 35 per cent of the fuel fired when firing 120 pounds per square foot of grate per hour. These tests show that the rate of combustion should be kept within ordinary limits, and that high-duty boilers should be designed to give greater rates of evaporation rather than greater rates of combustion. In other words, higher duties should be obtained by a re-design of the heating surface rather than by forcing boilers of ordinary design.

REVERSING MOTORS.

SOME MUCH-NEEDED DATA.

BY J. S. McKEE.

THERE seems to be a general complaint from engineers regarding the lack of information covering the time required to reverse an electric motor, the following item appearing in the February 6th, 1909, issue of the SCIENTIFIC AMERICAN:

"With all our scientific accuracy, we do not seem to

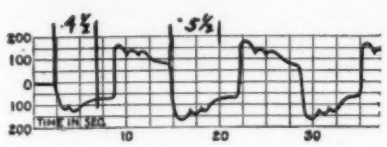


FIG. 1.

be able to secure from the manufacturers of electric apparatus any idea of the time in which a motor running at full speed in one direction will reverse to full speed in the opposite direction. There ought to be some reason for that lack of knowledge. Such information would be very useful to engineers."

There also appeared in the April, 1908, number of the Proceedings of the Engineers' Society of Western Pennsylvania this question, asked by one of their leading members:

"I would like to ask why it is that, with all our scientific accuracy, we do not seem able to secure from the manufacturers of electrical apparatus any idea of the time in which a motor running at full speed in one direction will reverse to full speed in the opposite direction? There ought to be some reason for this."

There is a very good reason for this lack of information and that reason is that it is almost impossible to secure exactly the same results in reversing motors even on duplicate installations. The time element for this cycle of operation is subject to so many variable conditions that positive preliminary information could not be given nor would it be policy for a motor manufacturer to tie himself down to a guarantee of results. The variable factors he would be up against would include the diameter, weight, and speed of the armature, the efficiency and capacity of the motors, the actual load on the motor, the condition of the load, that is, whether the load is capable of storing up some

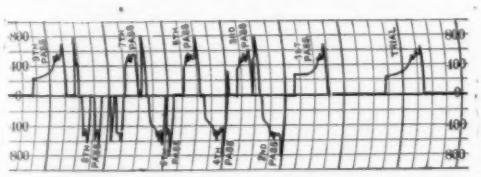


FIG. 2.

of the energy or whether it is entirely devoid of a "flywheel" effect; whether the machine has just been oiled or whether it has not been oiled for some time; the safe maximum current to get the best results must also be considered, together with the use of a proper automatic controlling apparatus.

Every electric motor possesses definite and inflexible characteristics; and to get the best operation under given conditions, a controller must be provided to adapt the motors to this condition. To duplicate this condition of operation day in, day out, *as nearly as possible*, an automatic controller developed for this purpose must be secured; so to give the engineers seeking knowledge on this line a pointer—go to the controller makers if you want to know what a motor can be made to do under any given condition. This entire question rests upon the controlling apparatus; and as controllers are usually a secondary consideration of the motor manufacturers, the request for information on this subject should not go to them.

The time of reversal depends greatly on the amount of strain you are willing to place on your motor and machinery. A certain time limit can be secured if the automatic controller is set so that it will allow only normal full load current through at any time. This time limit can be shortened by adjusting the controller to allow 25 per cent, 50 per cent or 100 per cent overload, depending, as above stated, on what the motor is good for and what risk you are willing to take. There is a point that can be reached in over-

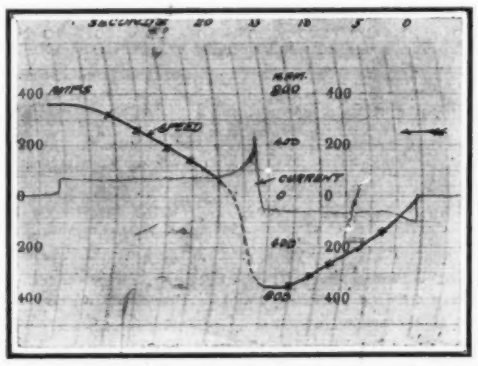


FIG. 6.

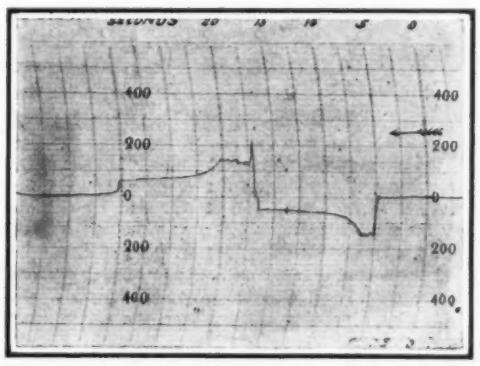


FIG. 7.

loading the motor, however, that will overstrain the windings and yet not make any appreciable difference in the time of reversal that could be obtained with much lower current.

An electrical engineer now connected with one of the largest steel plants in the world made the remark that "a few years ago we specified the motor to do certain work, and put any old thing on for a controller, even if it did not amount to anything more than a reversing switch, but now we order a motor that will be plenty big enough to do the work, and write our specifications out for the controller." In other words, it is the controller that decides the dependability and successful operation of the motor and machinery.

We are appending a number of curves showing actual operation of standard motors reversing under conditions described; these curves were taken with an Elliot Brothers recording ammeter, and the automatic controlling apparatus was built by the Electric Controller and Manufacturing Company of Cleveland, O.

Fig. 1 shows the operation of a 25-horse-power motor with the controller set to give 50 per cent overload. This overload is obtained only at the instant of reversal, the load on the motor is 75 per cent of capacity, the time required to bring the motor from full speed in one direction to full speed in the opposite direction, is 5½ seconds. This same curve shows the motor was brought from rest to full speed in 4½ seconds, requiring just 1 second to bring the motor from full speed to rest if 50 per cent overload was applied by reversal of the current.

Fig. 2 shows the curve taken on two 100-horse-power motors in actual operation on reversing tables in a blooming mill. This curve shows that it required 600 amperes to start these two motors, and they reached their normal speed in 3 seconds; at the instant of reversal they took 800 amperes or the normal full load current for the two motors, and reversed from full speed in one direction to full speed in the other direction in 3¾ seconds. The actual work being done by these two motors amounts to only 75 horse-power, or 37½ per cent of their capacity. The reason such large motors are used is because of the quick reversals required and consequent use of excessive power.

Figs. 3, 4, and 5 were made with a 50-horse-power motor, and show the increase in current values with the decrease in time of reversal, the motor conditions being the same in every case, the controller adjustment being changed for the various time elements. Fig. 3 gives 10 seconds for complete cycle with 320 amperes of current at instant of reversal and 280 amperes for acceleration; load on the motor, 120 amperes or 30 horse-power; giving 60 per cent overload for reversing, 40 per cent overload for acceleration, and the motor actually pulling a load of 40 per cent less than capacity.

Fig. 4 shows cycle of operation completed in 9 seconds, using 330 amperes at instant of reversal and 320 amperes for acceleration, giving 65 per cent overload at the instant of reversal and 60 per cent overload for acceleration and gaining one second in operation.

Fig. 5 shows cycle of operation completed in 7½ seconds, using 340 amperes at instant of reversal and 340 amperes for acceleration, using 70 per cent overload and gaining 1½ seconds over previous operation.

Fig. 6 shows operation of 25-horse-power motor pulling about 17 horse-power, the controller being arranged for extremely slow acceleration. This shows 100 amperes or normal load current to start, 60 to 70 amperes to accelerate, and 200 amperes at instant of reversal, and requires 17½ seconds to reverse from

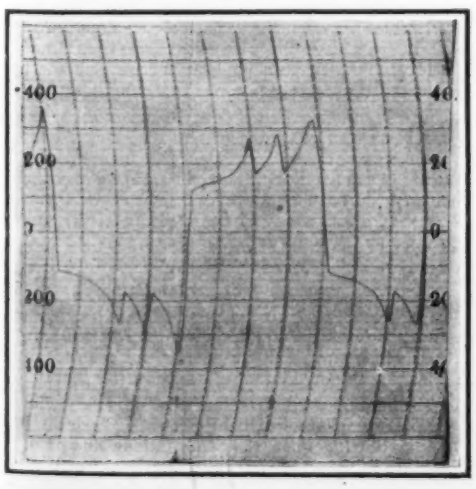


FIG. 3.

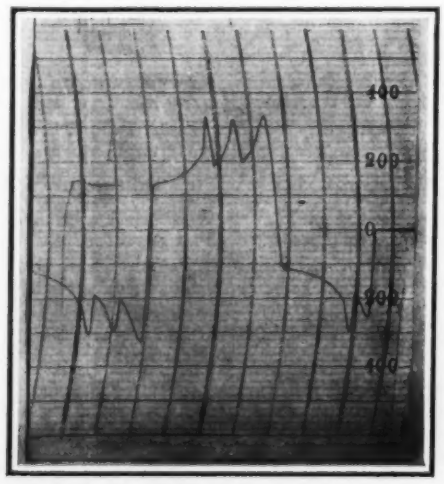


FIG. 4.

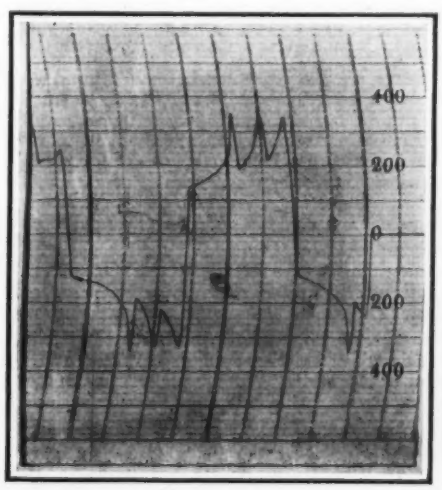


FIG. 5.

full speed to full speed. This curve also shows that the controller is arranged for five speed points. Also note that the automatic acceleration retards the closing of the switches, so that it requires 14 seconds from the instant of reversal for the last switch to get in.

Fig. 7 is the same apparatus as shown in Fig. 6, but the automatic acceleration is set for more rapid operation, the final switch closing in 3 seconds from instant of reversal. This setting of the controller allowed 140 amperes through the motor to start, 200 amperes for reversal, and 140 amperes for acceleration in the opposite direction, utilizing 40 per cent more than normal load capacity of the motor for acceleration, and actually 133 per cent more current than work accomplished by the motor required, yet the motor did not reach its normal speed for 12 seconds, gaining in this case 5½ seconds or 32 per cent in time at an expenditure of 133 per cent in current for acceleration.

We have used a value of 4 amperes per horse-power in all statements in this article, as this is close enough to real value for practical purposes.

Figs. 6 and 7 show the result of operating the motor with a flywheel load, Fig. 6 showing the motor put across the line in 14 seconds and full speed secured in 17½ seconds. Fig. 7 shows the switches closing across the line in 3 seconds, yet the motor did not reach full speed for 12 seconds, showing the effect of storing the energy in a flywheel load in comparison with the results obtained in Fig. 2, where there is very little flywheel effect, and consequent very rapid acceleration.

Fig. 2 is also interesting as showing the complete cycle of operations of a motor-driven blooming mill table during the reduction of one ingot.

We have tried to show in this article just what the engineer is putting the motor builder up against in asking the question given at the beginning, as we have shown several widely varying results where the motor and load conditions were the same exactly, and could further state that even with the same controller adjustment, there would probably be a slight variation if similar curves would have been taken a few days later, when the weather conditions might have changed, or there would be variations in results if curves were taken in the morning at starting up and again in the evening after a full day's run.

A motor can be placed on certain work, and the time to complete the cycle of operation can be easily found, and by adjusting the controller that time can be increased or decreased within certain limits; but it is hardly possible, even with all our scientific accuracy, to *say* exactly what can be done beforehand, although results can be approximated, and, after installation, satisfactory results can be secured by controller adjustment. This can best be illustrated by comparison. You might secure the ammeter charts of a power station for a year or more and make a very careful study of them, yet there would hardly be one chance in a million that you could develop a curve and say that the ammeter for "next Wednesday," or any other future day, would give that reading exact. It could be approximated, but there is no scientific method known for getting it absolutely correct, because "next Wednesday" might be a dark gloomy day with early peak loads, or it might be a bright day with a late peak load, it being almost impossible to duplicate conditions.

THE ELECTRIFICATION OF RAILWAYS.—II.*

AN IMPERATIVE NEED FOR THE SELECTION OF A SYSTEM FOR UNIVERSAL USE.

BY GEORGE WESTINGHOUSE.

Concluded from Supplement No. 1801, Page 23.

THE THREE-PHASE MOTOR.

On the three-phase system, the motor is inherently a constant-speed motor; it runs at approximately the same speed at light load and at full load; it runs at nearly the same speed up a grade as on level track, although the horse-power required on the grade may be several times that on the level. Conversely, it can run no faster on a level than it can climb a grade. In order to give a lower speed, however, the motors may be arranged upon the locomotive in pairs in a manner equivalent to the arrangement of two continuous-current motors in series, just described. Motors may also be arranged for two or more speeds, but this involves some complication in windings and connections. In all cases lower speeds can be secured by the introduction of resistances which increase the losses and lower the efficiency. In no case can the speed in any of the arrangements of motors be appreciably higher at very light load than it is at full load.

The motors are of the induction type without commutators and their inherent limitations, and are of relative simplicity in construction. The current is usually supplied at 3,000 volts from two overhead lines through two sets of current collectors.

With three-phase motors, as now constructed and arranged upon locomotives, it is possible with no additional complication so to utilize the motors when locomotives are moving trains upon a descending grade, that they become generators and return current to the line, a feature of value in certain mountainous districts but not of controlling importance in the selection of a universal system.

THE SINGLE-PHASE MOTOR.

The single-phase railway motor is a series motor with speed characteristics very similar to those of the direct-current motor, as the speed at a given voltage is greater or less, depending upon the load. The speed with a given load is also greater or less, depending upon the pressure applied to the motor; and this is not limited, as with direct-current motors, to that supplied by the circuit, and to one-half and one-fourth of that pressure, but is capable of adjustment to any desired degree of refinement by means of auxiliary connections from the secondary winding of the transformer on the locomotive, which is necessary for reducing the line voltage of 11,000 volts to the lower voltage required by the motors. Not only may numerous voltages less than the normal be arranged for lower speeds, but higher voltages can be provided to make possible speeds considerably above the normal. In this simple manner a wide range of efficient speed adjustment is secured which is impossible with other systems.

Like the throttle lever of the steam locomotive, the control lever of the single-phase locomotive may be placed in any one of its numerous notches to maintain the required speed. This facility of efficient operation over a wide range of speed and power requirements is one of the especially valuable features of the single-phase system. This difference, however, may be noted; the ability of the steam locomotive to maintain its speed continuously with heavy loads depends upon the capacity of the boiler; on the other hand, the electric locomotive has an ample supply of energy available, drawn from a large power house, and the limit of its endurance is determined by the safe temperature of the motor.

The question of determination of the frequency for use on single-phase railways is one of very great importance. Twenty-five cycles is in general use for power transmission purposes and has been adopted by nearly all the single-phase railroads now operating. The Midi Railway of France has adopted 15 cycles. The lower frequency permits of a marked reduction in the size of a motor for a given output, or conversely of a considerable increase in output from a motor of given dimensions and weight. Three-phase installations in nearly all cases employ approximately 15 cycles. The choice of frequency is one of the most involved, difficult and important problems now presented for solution.

SUMMARY.

Locomotives equipped with each of the three types of motors have been in successful operation and have demonstrated their usefulness, capacity and reliability in practical railway service. The three-phase motor, having a definite constant-speed characteristic, is particularly adapted to certain conditions; but on the other hand it has a less general adaptability to the ordinary varying conditions of railway operation. The single-phase motor has a facility of voltage control which gives an efficient means of speed adjustment, and is in this particular superior to other systems. The relative weights and costs of the several types of motors, and of the locomotives designed to accommodate them, depend upon so many conditions that comparisons must necessarily be general. It will be found, however, that these differences in locomotive cost are in many cases more than offset by the cost of the other elements in the electrical system.

The control apparatus for all types of locomotives has been developed so that it is reliable and convenient in operation. For each system a small master controller serves to operate by auxiliary means the necessary electric switches for the control of the motors of one locomotive, or to operate simultaneously as a single unit the motors on two or more locomotives or cars in a train.

TRANSMISSION OF POWER FROM POWER HOUSE TO LOCOMOTIVE.

The controlling factor in the cost of electrification in nearly all cases is the system for transmitting power from the power house to the locomotive, and not the locomotive itself. The choice between the several systems must, therefore, be based upon a comparison of the complete systems. The differences between the methods of transmitting power are of far greater importance than the differences between power houses or between locomotives. The current for all systems is generated in usual practice as high-tension alternating current, for the reason that electric energy can be most economically transmitted by high-tension alternating current even though it is in some cases converted into direct current.

THE DIRECT-CURRENT SYSTEM.

For the direct-current locomotive the apparatus which intervenes between the alternating current-generator and the locomotive consists of a number of links or elements through which the electric energy must pass, one after the other. These consist of:

a Raising transformers in groups of three.

b A transmission line of three wires, sub-stations, which require attendance, containing

c Transformers in groups of three, and

d Rotary converters for receiving the alternating current and delivering direct current.

e A third-rail contact conductor, which for heavy work must often be supplemented by copper feeders.

f The track return circuit, which must be provided with heavy bonds, and in certain cases supplemented by feeders and so-called negative boosters.

It is necessary to maintain the alignment of the third rail within close limits both in its distance from the track rails and in its elevation above them, as the contact shoe can have only a small range of automatic adjustment.

THE THREE-PHASE SYSTEM.

For the three-phase locomotives the respective links between the generator and the locomotive are:

a Raising transformers in groups of three.

b Transmission line of three wires.

c Sub-station transformers in groups of three.

d Two overhead wires as the contact system.

e A track return which usually requires nothing but inexpensive bonding.

The two overhead trolley wires require a double system of overhead construction, as the wires must be kept separate and well insulated from one another; the two must be maintained at equal height above the track and at switches and cross-overs the construction is complicated.

THE SINGLE-PHASE SYSTEM.

For single-phase locomotives there is:

a A raising transformer.

b A transmission line of two wires and sub-stations widely spaced, each containing

c A lowering transformer, which supplies

d A single trolley wire.

e A track return, usually requiring nothing but inexpensive bonding.

In certain cases where the distance from the power station is not more than 15 or 20 miles, the single-phase trolley can be supplied directly from the power house, so that only one single element, i. e., the trolley wire, intervenes between the generators and the locomotives.

The single trolley wire permits a relatively wide range in height, as the pantagraph trolley automatically adjusts itself to the position of the trolley wire. In some cases the wire has a normal height of 22 feet, but is carried under bridges where the limit is 15½ feet.

The three types of railway motors, and the three respective systems for conveying power from the generating station to the locomotives, have all successfully demonstrated their ability to operate railway trains. It is not my purpose to urge the adoption of a particular system, but rather to point out some of the well-known characteristics of these systems which have a bearing upon their limitations and their general adaptability to railway conditions, and to urge the great gain which will result from a single universal system.

* Read before the American Society of Mechanical Engineers.

REQUISITES FOR A UNIVERSAL ELECTRIC SYSTEM.

In selecting a proper electrical system for railway operation, it will probably be generally conceded that the following elements are of prime importance:

a The electric locomotives should be capable of performing the same kinds of service which the steam locomotives now perform. This will be most readily secured by electric locomotives which can practically duplicate the steam locomotives in speed and power characteristics. This includes a wide range of performance, embracing through passenger service at different schedule speeds; local passenger service; through freight service in heavy trains; the handling of local freight by short trains; and a variety of switching, terminal and transfer movements. This naturally calls for wide variation in tractive effort and in speed, both for the operation of different kinds of trains, and also for the operation of the same train under the varying conditions usually incident to railway service.

b The electric locomotive should be capable of exceeding the steam locomotive in its power capacity. It should be able to handle heavier trains and loads, to operate at higher speeds, and in general to exceed the ordinary limits of the steam locomotive in these regards. The readiness with which several electric locomotives can be operated as a single unit enables any amount of power to be applied to a train.

c The electric system should adapt itself to requirements beyond the ordinary limitations of the steam locomotive in small as well as large things. It should be adapted for use on branch lines, and for light passenger and freight service similar to that so profitably conducted by interurban electric roads, which in many cases run parallel to steam roads, not only taking away the traffic of the steam roads, but building up a new and highly profitable traffic, both in passenger and in express service.

d A universal electrical system requires that power should be transmitted economically over long distances and supplied to the contact conductor. The system should utilize the most highly perfected apparatus for the electric transmission of energy and its transformation into suitable pressures for use.

e The contact conductor in an ideal system should be economical to construct, both for the heaviest locomotives where the traffic is dense, and for light service on branch lines. It should impose minimum inconvenience to track maintenance; should give minimum probability of disarrangement in case of derailment, or in case of snow and sleet, and should in general be so placed and constructed as to give a maximum assurance of continuity of service.

The use now made of electricity in steam railway service has been brought about, generally speaking, through compulsion. The steam locomotive has reached its limitations and has been found unsuitable and inadequate in tunnels or in terminal service. Even where other considerations may have been controlling, the problem has usually been a specific one of electrifying a relatively small area. The problem has been solved by considering those factors which were of immediate importance, without giving weight to uniformity with other systems or of extension.

Now the natural course of development will be the extension of these limited zones, until after a time they meet. Then there will arise great inconvenience and expense if the systems are unlike. For the present it may be a matter of little moment whether different systems have their contact conductors in the same position, or whether the character of the current used is the same or different. As previously stated, in the early days of railroading, it was of little consequence whether the tracks of the different systems in various parts of the country were alike or unlike, but later it did make a vital difference, and the variation resulted in financial burdens which even yet lie heavily on some railways. It is this large view into the future of electrical service which should be taken by those responsible for electric railway development.

THE FUTURE OF ELECTRIFICATION OF RAILWAYS.

The complete electrification of a railway will necessitate a rearrangement of ideas and practices in regard to operations. Coaling and watering places will not be needed; passenger trains will be differently composed, some classes being of less weight; and they will operate more frequently, thus promoting travel; other trains will be heavier than at present, or will operate at higher speeds, and branch lines, by the use of electrically fitted cars, can be given a through service not now enjoyed.

The movement of freight will undergo great changes, due to the fact that electric locomotives can be constructed with great excess capacity, enabling them to move longer trains at schedule speed on rising gradients.

The large percentage of shunting operations due to steam locomotives will not be required.

The railway companies can combine upon some coöperative plan for the generation of electricity, thereby effecting large savings in capital expenditures, and can utilize their ow- rights of way for the transmission of the current, not only for the operation of trains but for many other useful purposes.

Notwithstanding the fact that great strides have already been made in cheapening the cost of generating electricity by steam engines, I foresee, from the progress made in the development of gas and oil engine power, a still further reduction in cost which will accelerate the work of electrifying existing railways.

There will be serious difficulties to surmount in the selection of a general system. There naturally will be arguments in favor of one or another of the systems now in use and the inclination of those who have adopted a particular system to advocate its general use. There will be enthusiastic inventors, and there will be many advocates of the common view, namely, that there is room for several systems and that each system will best meet the requirements of a particular case. There will be those who give undue weight to some feature of minor importance, such as a particular type of motor or of locomotive, instead of giving a broad consideration to the whole system, and recognizing that, in the general problem of railway electrification, facility and economy in transmitting power from the power house to the locomotive, are of controlling importance.

Were there now only one system to be considered, there would be a concentration of the energy of thousands on the perfecting and simplifying of the apparatus for that system, to the advantage of railway companies and of manufacturers.

TURBINES AND PROPELLERS.

OUR readers cannot have escaped the knowledge that for a long time past the combination of turbines and screw propellers in ships has constituted a question the interest of which grows. Put in the simplest possible way it means that the highest efficiency speeds of the two are incompatible. Consequently invention is hard at work to get rid of this incompatibility. Before any proper presentment of the problem can be made, it is essential that the word "speed" should have its meaning defined very precisely. Now speed can be expressed in this case in two ways. We may talk of revolutions, or of angular velocities. Let, for example, a propeller have a diameter of 10 feet, and make 150 revolutions per minute, then its velocity may be expressed as 4,712 feet per minute, or as 150 revolutions. Take again a turbine 3 feet in diameter making a fraction under 1,000 revolutions per minute, and we may speak of its velocity as 9,425 feet per minute, or as 1,000 revolutions. The word "revolutions" is most frequently used because it is convenient, and certain things are taken for granted. But of course there is no hard-and-fast connection assumed to exist between them. A turbine 6 feet in diameter would have the same blade velocity as one 3 feet in diameter making double the number of turns per minute. So much premised, we may proceed to consider in detail the nature of the problem.

To begin with the turbine, certain conditions are fixed for each ship as to diameter; and given the diameter, and the pressure, and the design of the turbine, the angular velocity is known at which the blades must run to give the greatest torque with the least coal. But the available space being known, this means in other words that the number of revolutions to secure maximum turbine efficiency is known. Again, the diameter of the propeller may be regarded as fixed within narrow limits. The diameter settles the number of revolutions of maximum efficiency. This number is supposed to depend on the design of the propeller; its precise position; direction of turning to the right or to the left; its material, and some factor the nature of which has yet to be found out. It is certain, however, amid much that is far from being certain, that the screw must make a smaller number of revolutions than does the turbine—except, perhaps, in such craft as torpedo destroyers. For large ships such as the "Mauretania," and for "tramps" on the other hand, the velocities are incompatible, as we have said, and the problem of the hour is how to couple up two large shafts so that each may run at the proper speed. We shall not be wide of the mark if we take 80 revolutions per minute for the screw and 800 for the turbine as likely to give results nearly, if not quite, as good as can be secured by any others, higher or lower. In the case of fast liners a much higher velocity of screw is permissible, and because of the large diameter that can be given the turbine its velocity of rotation may be reduced very much below 800 turns per minute. There is, besides, a margin of variation in speed which, kept within, reduces efficiency by but a small percentage. It may be taken as a general statement meeting the facts very fairly, that nothing more is wanted in the way of speed reduction than about four to one. Let the turbine make four revolutions for one of the screw and the necessities of marine propulsion would be fairly satisfied.

There are four forms of reducing gear available. We have first toothed wheels; secondly, pitch chains; thirdly, water, and lastly, electricity. Reduced to its simplest terms, the problem is how to couple two shafts, one driving, the other driven, in such a way that there shall be least noise, vibration, and loss of power in the transmission. When the screw propeller was first introduced its speed was too great for the slow-running marine engines of the time, and the engine shaft carried a spur wheel with wooden cogs which geared with a cast iron pinion on the screw shaft. The wheels were usually multiple—that is to say, three or even more were placed side by side on the shaft and "stepped" to reduce noise and backlash. At that time the far superior helical gear had not been invented. The Melville-Westinghouse arrangement is the candidate for favor at this time. The wheels are very wide on the face, cut with great care, and mounted in a "floating frame," intended to permit such small movements in the way of automatic adjustment, that there shall be neither vibration, noise, nor backlash. Pitch chains were used in early steamers, but they were not then a success, because they were inaccurate to begin with, and wear and tear made them worse. But in the present day chains can be turned out with minute accuracy; and in such a way that wear and tear must be very small. The area of the surfaces in contact is very much larger than it can be in any other form of gearing. The bearing surfaces can be very hard, and there is, we hold, no reason why very large powers may not be transmitted with silence and success by chains. The use of chain transmission gear is, indeed, extending every day, and it will probably receive an adequate trial at sea before long. Next comes water. The theory is extremely simple. The turbine drives, let us suppose, a set of pumps with pistons of a given diameter. The screw shaft is caused to revolve by a water engine similar in construction, with pistons or plungers twice the diameter. Then four revolutions of the pumps will compel one revolution of the motors, and the screw will turn round once while the turbine turns round four times. Last of all, we have electrical reducing gear, in which the turbine runs at any speed desirable, and by means of a dynamo supplies current to drive a motor on the screw shaft, which will make any number of revolutions we please.

It may be assumed that any one of the four methods of transmission named will do its work. The questions remain, at what loss, and at what first cost? Unfortunately, to these questions it is almost impossible to obtain a definite answer based on experience. The discussions which have taken place so far leave us nearly where we were. As far back as July, 1908, Mr. W. P. Durtnall read a paper before the Institute of Marine Engineers advocating electrical transmission. Since that date it has been frequently before the public. It has been brought forward again before the Institution of Naval Architects, and forms the subject of a controversy now going on in our correspondence columns. On the whole, the criticism to which the scheme has been subjected is by no means unfavorable, if we except one cryptic statement made by Mr. Parsons to the effect that the result of a short-circuit in the engine-room would be the sudden death of every one there. A hard saying, to which it is difficult to attach any meaning.

The whole question as it stands is really one of degree. If the turbine is used to drive the propeller in any ship there will be loss, the amount of which decreases with the speed of the ship, because the faster the ship the nearer can the velocities of the turbine and the propeller be made to approximate to those of maximum efficiency. In the cargo boat, or at indeed any speed under about 18 knots, the loss is so serious that the turbine is not able to hold its own with first-class reciprocating engines. Some kind of reducing gear must be introduced. In any case there will be loss. Without the gear both the screw and the turbine lose efficiency. With reducing gear there is also a loss. Which will be the greater? May it not yet be found possible to construct a turbine on the Laval principle of very large diameter and yet quite short, which will take up little more room than would a big fly-wheel, and give a high vane angular velocity while making a moderate number of turns? No violent stretch of the imagination is required to picture a turbine 25 feet in diameter driving a screw direct at 100 revolutions per minute and 9,500 feet of blade speed per minute for the outer rows. Of course, objections may be urged; we do not think they will be found insuperable. There is, however, one point most important of all to be settled, what will the ordinary tramp steamer gain by substituting turbines for piston engines? About this no one seems to have anything definite to say, and yet it is *the* question after all.—The Engineer.

USEFUL SHIPYARD MACHINE.

UNIVERSAL SHEAR FOR CHANNELS, ANGLES, AND PLATES.

THE need in shipyards for a machine to cut square or mitered the various channels and angles required for shipbuilding purposes, has been met by the machine shown in the accompanying half-tones.

While especially built for the Marine Department of the Maryland Steel Company, Sparrows Point, Md., this machine is intended for the use of any class of iron workers. It is provided with a coping attachment at one end of the machine; a plate shear at the other; and two angle shears, operating at an angle of 45 deg., in the center of the frame. The last have a capacity for cutting up to 15 x ¾-inch channels, and 6 x 6 x 1-inch or 8 x 8 x ¾-inch angles. The plate shear has a capacity for 1-inch material. Each shear is controlled by its own clutch, and the machine may be operated by different groups of men all working at the same time, and without interfering with one another.

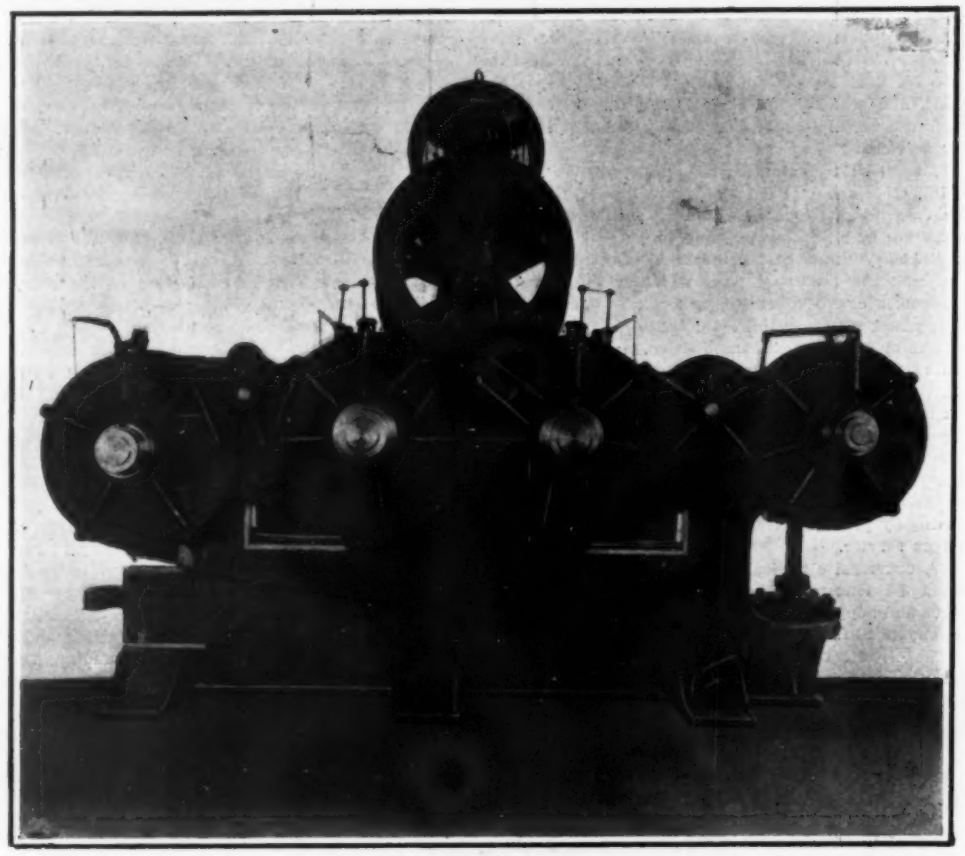
The frame, plungers, pendulums, clutches, and all parts subject to shock are made of semi-steel castings. Hammered steel shafts, containing 0.4 to 0.5 carbon, are used for the shafts, and the question of lubrication has been given especial consideration.

The gears are provided with long sleeve hubs, and the covers which protect the gears are bored to receive them. The gears in turn support the shafts, which have bearing surfaces throughout their length.

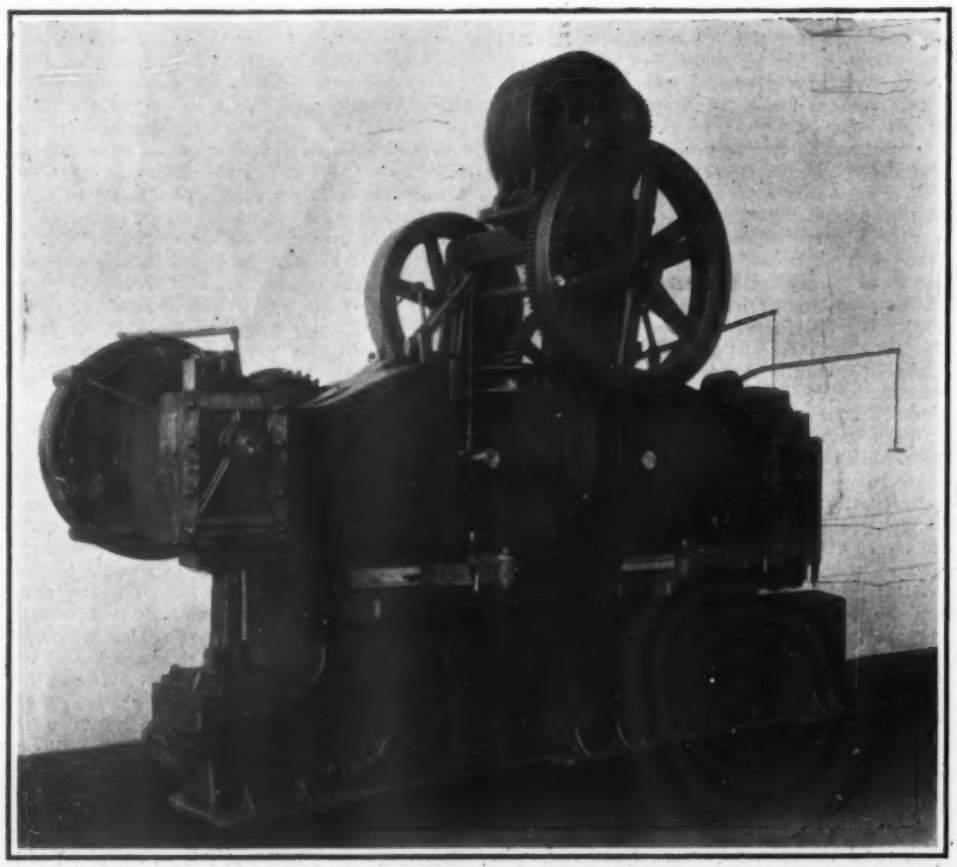
A patent stop motion is used, which automatically throws out the clutch on each shear when it reaches its highest point. For the coping attachment, which may also be used for punching, the stop mechanism is adjustable so that the plunger may be stopped in any point of its down stroke.

It will be noted by referring to the engraving that the plates for supporting the angles or channels while being cut are so placed that they are out of the way of plates while being sheared as the latter pass under them.

The machine as represented weighs about 23 tons. It is driven by a 25-horse-power electric motor, and is manufactured by the Covington Machine Company, Covington, Va.



REAR VIEW OF THE MACHINE, SHOWING THE AUTOMATIC CLUTCH MECHANISM ON THE OPERATING GEARS.



FRONT VIEW OF THE MACHINE, SHOWING THE TWO ANGLE SHEARS AND THE COPING ATTACHMENT AT THE LEFT.

RAYS OF POSITIVE ELECTRICITY.

PROF. J. J. THOMSON, in the Philosophical Magazine, writes on his experiments with the rays of positive electricity. In previous experiments, the streams of positive electricity were produced by means of an induction coil. When discharges are produced in this way the potential difference between the terminals varies considerably during the discharge, and the method is not suitable for those experiments in which accurate measurements of the potential difference during the discharge are essential. A Wehrsen (Mercedes) electrostatic induction machine is therefore employed, and by this means observations on the canal rays are made with potential differences varying from 40,000 to 3,000 volts. Experiments are described which show that the velocity of the particles is the same when the pressure is very low, and the potential difference between the electrodes 40,000 volts, as when the pressure is higher and the potential difference only 3,000 volts. It thus appears that when the pressure is high the velocity of some of the positively charged particles is greater than that which could be imparted by the electric field, as the particles move from the place where they are liberated up to the kathode. The place where the positively charged particles are produced can, by observation of the shadows thrown by obstacles placed in front of the hole in the kathode, be shown to be the region near the boundary of the dark space; thus if the particles when liberated were positively charged, the velocity they would acquire from the electric field would be that due to a fall through the dark space; hence if this were the source of their velocity, a passage back through the dark space from the kathode to the anode would bring them to rest at the boundary of the dark space, and they would not travel any further down the tube. Experiments are described to test this point, and as a result of these it is concluded that the great speed of the canal rays is not due to the direct attraction of the kathode on their positive charges. It is suggested that the velocity of the positive particles when they have traveled some distance from the kathode is determined by the properties of a system of dissociating neutral doublets; such doublets appear to compose the canal rays, or at least those which are deflected by electric or magnetic forces. It is also found that the "retrograde rays" have the same velocity as the canal rays over wide variations of potential difference. In the case of these rays it would appear that the electric field produces some kind of polarization in the molecules which makes them eject the uncharged doublets along the line of motion of the kathode rays in their neighborhood. While there is no question that the canal rays originate in the region near the outer boundary of the dark space, the place of origin of the retrograde rays is more difficult to fix. Experiments seem to indicate that some of the retrograde rays start from the positively electrified first layer, and not from the metal of the kathode.

Tests of mining cages were made recently at the Moodna pressure tunnel of the Catskill aqueduct to determine the efficiency of the safety devices before allowing their use. One of the cages was suspended from the head frame by a hemp rope instead of the wire cable regularly used. This rope was then cut with an ax; the safety dogs allowed the cage to descend only a couple of inches.

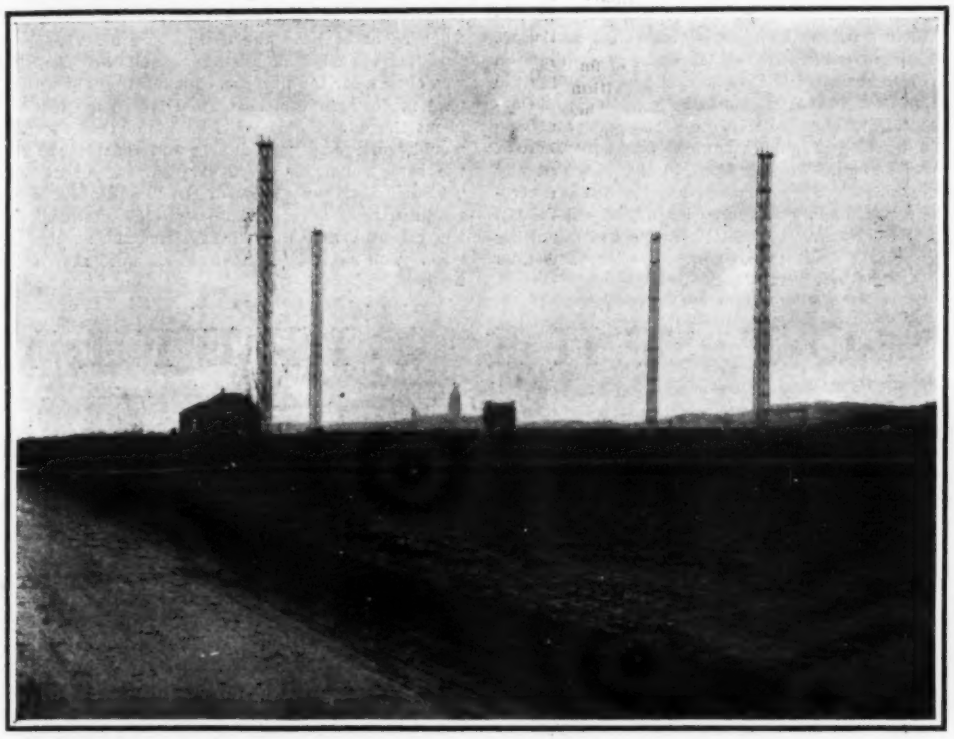
A NEW SYSTEM OF WIRELESS TELEGRAPHY.

THE BELLINI-TOSI APPARATUS.

BY THE PARIS CORRESPONDENT OF THE SCIENTIFIC AMERICAN.

IT will be remembered that the two Italian engineers, Bellini and Tosi, were very successful with their new method of directed waves for use in wireless telegraphy. The first experiments, of which we have already given a full account, were made between temporary posts located on the Channel coast of France at Dieppe, Havre and a third point. By this means, messages could be directed to one of the points and the station lying near by could not receive them. On the contrary, when we receive a message we are able to find the angle of the sending station within one degree on the horizon, and this is a remarkable result. Instead of erecting a vertical antenna, they use an aerial in the form of a loop which would send waves in but one direction counting front and back. Crossing this loop by a second and perpendicular one, we can send in a right-angled direction. Should we now partially excite both loops, the resultant direction of the waves will depend on the amount of exciting each loop, so that we can vary the direction of the waves all around the horizon. The radio-goniometer, or rotating inductive coil, is the apparatus used to excite the two loops variably by turning one of its coils about the center so as to direct the waves. For receiving, we use a similar coil and listen in the telephone until turning the coil gives us the loudest sound. The angle of the distant post is then very closely shown upon the dial.

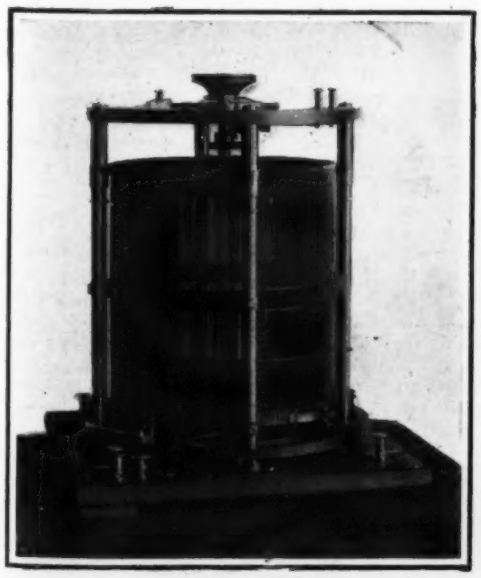
The French Government has taken up the matter and a wireless post on the Bellini-Tosi system, of which the apparatus was built at the Ducretet establishment, has been erected on the Channel coast at Boulogne. The new station is laid out so as to conform as nearly as possible to the conditions which theory shows to be the most suitable, at the same time making such variations as are needed to carry out the construction of the towers and antenna wires from a practical point of view. There are erected four metallic towers built of structural iron, and these occupy the four corners of a square. A height of 153 feet was given to the towers, while the square surface of ground covered by the same is 265 feet on a side. Connecting the tops of the towers are four main horizontal cables, also forming a square, and the antenna wires are hung down from these cables to the ground. According to the Bellini-Tosi system there are needed two pairs of antennæ, these lying on the opposite sides of the square. Considered singly, each of the four aerial systems hanging from the horizontal cables is made up of six copper wires which run down to a point near the ground in a vertical direction, the wires being spaced 13 feet apart. The lower end of the wires stops at 26 feet from the ground, and the upper end, taking account of the sag of the horizontal cable, is at 146 feet height. The assemblage of antenna wires on a side is not vertical, but descends in an inclined direction away from the top and forming an angle of 32 degrees so that the antennæ spread out considerably at the bottom. The lower ends of opposite antennæ are thus 420 feet apart, while the upper ends correspond to the width of the square.



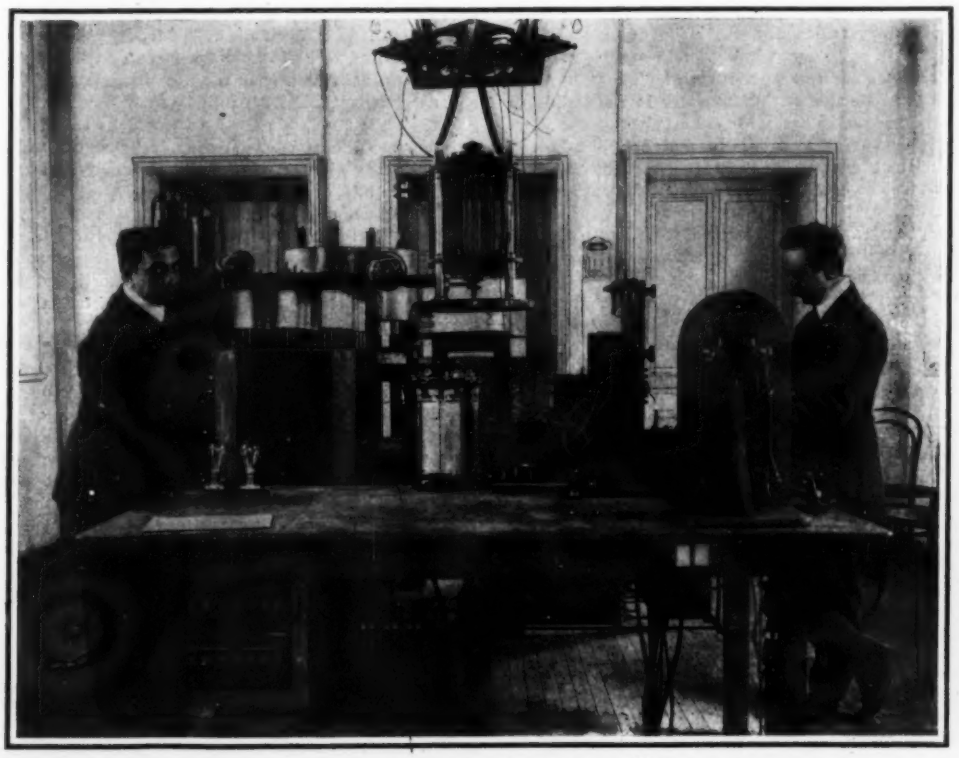
FOUR METALLIC TOWERS OF THE WIRELESS STATION AT BOULOGNE, FRANCE.

Seeing that the wave length chosen for operating the present station is 300 meters, the spread of the antennæ should have been half this length in order to give the best results, but as it was not desired to cover too much space of ground by the four towers along with their guy-wires, the present spread at the bottom of the system was considered to be a close enough approximation. The six vertical wires of an antenna are cross connected at the bottom, and from this point a wire leads into the station building which is located at the center of the square. In this way we have the characteristic form of aerial used in the present method, each aerial consisting of two upright (or inclined) antennæ joined by a horizontal wire at the ground, and the two main aerials cross each other in vertical planes in order to form the directive system as we have already seen. It was desired to obtain very conclusive measurements as to the performance of the new station, and to carry this out they erected a testing station at about 2 miles distant. Here was installed a vertical antenna and a Duddell thermo-galvanometer for measuring the amount of energy radiated from Boulogne. The results showed that the energy radiated by the Bellini-Tosi system in one direction is six times what would be radiated uniformly by an ordinary vertical antenna.

The results obtained at the testing station at short range were confirmed by a series of experiments at long distances, and these tests showed that the type of antenna peculiar to the directive system has a greater range than the antenna of the usual type under the same conditions. The long range tests were made in the first place with a station on the English side of the Channel at Folkestone, which lies at a comparatively short distance of 25 miles, and afterward at more distant posts such as the station on the Mediterranean coast lying near Marseilles and also the post which was recently erected by the government near Algiers. The results of the trials showed that the



RADIO-GONIOMETER FOR RECEIVING. WHICH LOCATES A DISTANT POST BY ONE DEGREE ANGLE.



RADIO-GONIOMETER IN THE MIDDLE AT THE TOP. THE TWO INVENTORS.

distant stations could always receive the signals very clearly when the Bellini-Tosi system of directed waves was employed, while the signals sent from the ordinary vertical antenna were found to be much weaker. Outside of the question of directing the waves, this is a point which is greatly in favor of the new method, and this is confirmed by official tests at long distance, namely, 960 miles to the Algiers station, of which a great part or 660 miles is overland. It is to be noticed that in the present trials of the system there was a comparatively small amount of power employed at the Boulogne post, this being not over 500 watts (2/3 horse-power) in the primary of the induction coil, and the wave-length of the post is under the ordinary, being but 300 meters. On the other hand, the messages coming from the distant posts are better received when using the new apparatus, both when using the ordinary vertical antenna or a single one of the Bellini-Tosi antenna to operate on the common method.

Owing to the fact that it does not use a ground connection for the antennæ, the new system is of advantage in countries where the earth is a poor conductor owing to lack of moisture. Previous researches made by Sir Oliver Lodge and M. Tissot show that the earth offers a considerable resistance and thus absorbs a certain amount of energy. The resistance is naturally greater in the case of dry ground, and especially in desert regions this may become so high that it causes great difficulty in the working of an ordinary antenna.

It will be observed that the present form of antenna, which does not use a ground connection, will prove much superior when it comes to dealing with such cases, as the results will be the same regardless of the nature of the ground.

Some of the most interesting points about the new method are the services which it can render to navigation. The Boulogne station is placed in a position where an ordinary post could seldom operate without being disturbed by waves from other sources, seeing that it is surrounded by a great number of wireless stations on the English Channel and elsewhere in the neighborhood. Using directed waves, we are in a much better position to have a constant service between the Boulogne station and vessels. By this means we can also carry out what will no doubt be a useful improvement, namely, that of allowing vessels carrying a wireless post of the ordinary kind to take their position in time of fog when the coast points are invisible. In fact, it being given that the receiving instrument at Boulogne allows of finding the direction of a distant transmitting post within an approximation of one degree, we can receive the signals from a vessel and find its angular position. Data of this position are again signaled to the vessel at any given moment. By repeating this operation according to the commonly-used methods of navigation, the vessel is able to take its position in time of fog owing to the signals from the Boulogne station, and thus we have a distinct advantage.

M. Tosi mentions another use of the method in navigation, which has not been before brought out. This application allows a vessel to determine its position when it comes within range of a wireless post of any kind. The position is found in the same way as we make the readings when in view of the coast with the usual azimuth compass. In fact, if we install upon the vessel a pair of small crossed aerials on the Bellini-Tosi method and disposed in the proper way, connecting them to a receiving radio-goniometer, we can find the reading for a shore wireless station with the same degree of precision as when using an azimuth compass with a visible object. The vessel can thus take the reading for a known point and can determine its position in the usual way. As it was of interest to find whether such a method could be actually used upon a vessel at sea, the investors made an arrangement with the Compagnie Générale Transatlantique so as to have the aerials and other apparatus installed upon one of the liners, and the "Louisiane" was chosen for the purpose. During the trip which M. Tosi made upon this boat from Havre to New York, about the end of last year, he found that the device would work very successfully and that it had about the same range as the usual compass, or 25 miles. Together with the officers of the "Louisiane," he took readings upon several visible wireless stations, using the compass and the wireless method at the same time. The readings in these cases were always identical.

THE LIGHT OF THE FIREFLY.*

LUMINOSITY WITHOUT HEAT.

BY DRS. H. E. IVES AND W. W. COBLENTZ.

UNDER the title "The Cheapest Form of Light," Langley and Very published nearly twenty years ago[1] a photometric and bolometric study of one species of firefly, "Pyrophorus Noctilucus" found in Cuba. The investigation showed this firefly to possess the great desideratum in illumination "light without heat," its radiation consisting of a band in the yellow-green of the spectrum, falling off rapidly toward red and blue. The spectrophotometric work was confessedly unsatisfactory, being done visually and hence hindered by the unsteady character of the light, as well as its low intensity. The authors satisfied themselves that the spectrum, as compared with sunlight, was shorter, not extending far into the blue or beyond the red, and that its maximum lay at .57μ. The accuracy of the visual work was not sufficient, because of the difficulties encountered, to draw an accurate energy curve, or to detect minute spectral structure if it existed. Both because of the small amount of energy and its unsteady character direct determination of the energy in the visible spectrum by bolometric means was hopeless.

In the present investigation the attempt was made to secure a more exact idea of the energy distribution in the firefly light in the visible spectrum by means not available to the previous investigators. In place of visual observations use was made of photographic plates sensitive to the whole visible spectrum. The considerations leading to the use of photography are as follows: With a radiation meter it is possible to measure radiant energy in the visible spectrum directly, provided the source measured is steady and has sufficient energy to affect the instrument. The energy must be considerable, since instruments of this kind are many thousand times less sensitive than the eye or photographic plate for radiation less than .65μ in wave length. With the spectrophotometer it is possible to measure the distribution of visible radiant energy, even if of low intensity, indirectly, by comparing the source with one of known energy distribution, provided again the source measured is steady. If the source measured is unsteady as well as weak neither method of measurement is applicable. For cases of this kind the photographic plate as a record of incident energy is the only resort. Its great advantages are first, that all portions of the spectrum are recorded simultaneously, so that unsteadiness of total light is no disadvantage; second, the action of the plate is integrative and therefore the obstacles imposed by low intensity may be overcome by long exposure. A further advantage for the present purpose is that the plates used, Wratten and Wainright "Panchromatic," taking advantage of recently discovered sensitizers, are sensitive to all colors of the spectrum and therefore record the whole spectral extent of the firefly light (if limited as indicated by Langley's work).

The apparatus consisted of a large prism spectrograph having a dispersion in the yellow sufficient to separate the yellow mercury lines by about half a millimeter, and giving a spectrum of about seven centimeters length in the visible. A helium tube and a carbon glow lamp carefully calibrated for watts per candle served for comparison sources, one for a wave length scale, the other as a standard of energy distribution.

The fireflies were of the species common in Washington early in July "Photinus Pyralis." These are much smaller than the West Indian genus, averaging about 12 to 15 millimeters in length, of which length only about one-half is luminous. The light ordinarily consists of a faint glow, which at periods of a few seconds flashes out with greatly increased intensity, the peculiarity which has earned the popular name of "lightning bug." Under the microscope the light giving portion is seen, when not giving out the bright flash, to be made up of numerous small irregularly scintillating points, reminding one of the spintharis-cope. It was at first attempted to secure sufficient light by inclosing a number of the insects in a small cage with a white wall from which the light would be reflected into the slit. It was found however that fireflies in captivity quickly lose their desire to flash, and this scheme was abandoned. The only satisfactory method proved to be to hold the insects in the fingers one or two at a time over the spectroscope slit. The best specimens would flash as frequently as every three seconds until tired, when others would be substituted for them. Others, after a period of flashing, would yield a steady glow of considerable intensity. With a fairly wide slit, exposures to the fireflies, taking them as they came, amounted to from two to six hours. The work was done evenings and extended over about two weeks before three satisfactory negatives were obtained, one of long exposure, one of short, and one (short exposure) with a very narrow slit, taken with a view to detecting any irregular structure.

The spectrum of the firefly light is confined to a band in the yellow-green, ending in the blue-green on one side, in the red on the other. The limit on the red side is so far from the limit of sensitiveness of the plates as to leave no doubt that the firefly's spectrum does end within the limits of the visible spectrum. Langley concluded from his bolometric work that there is no emission of energy in the infra-red. If this is true the complete energy curve may be obtained from the energy emitted in the visible spectrum. From the exposure made with very narrow slit there is no evidence of fluted or other irregular structure.

The distribution of energy was obtained by measurements of the density of the photographic plates. As is well known, the relation between exposure and density is not the same for all exposures. For a limited range density is proportional to exposure, beyond this range saturation sets in; still farther away, reversal. It is therefore necessary to know accurately the exposure equivalent of each density on the plate measured, in other words, to know the "characteristic curve." With this end in view a series of exposures of known relationship were made on the carbon glow lamp, in which the densities covered practically the whole range of those in the two best firefly negatives. All the negatives, it should be noted, were developed under identical conditions, by time, in complete darkness, and should therefore be as nearly comparable as possible without all the exposures in question being made on one plate. The densities of all negatives were measured by means of a Martens polarization photometer, mounted on a dividing engine, in such manner that strips 1 millimeter wide and 1 millimeter apart were compared for blackness against the clear unexposed plate. One of the helium lines served as reference mark, and the points of measurement were the same on all plates.

From these observations density curves were plotted. From the longest firefly exposure a set of points were so determined for the fainter portions of the energy curve; the stronger portions lay beyond any of the comparison exposure curves, in the region of saturation, and therefore unsuitable for measurement. From the short exposure, in which the densities were all below the region of saturation, the intermediate points of the curve were determined. The two curves overlapped for a short range, from which the multiplying factor to bring them to a common unit was determined.

From the values so obtained the ratio $\frac{\text{firefly light}}{\text{glow lamp light}}$ was derived for each point of density measurement. That is, there was obtained the spectrophotometric relationship between the two. The numerical values are given in Table I, column 5.

At this stage it becomes necessary to know the energy distribution of the carbon glow lamp. This can be obtained directly by radiometric methods, the source having the qualities both of steadiness and comparatively large amount of energy.

The spectrophotometric measurements of the complete energy distribution of the carbon glow lamp employed were made by two methods, one suited best for the longer wave lengths, the other for the shorter, and which gave very concordant results over their common range. In the first method an improved and highly sensitive bolometer, a fluorite prism, and mirror spectrometer[1] were employed to obtain the spectral distribution of energy from .55μ to 4μ in the infra-red, where the glass walls of the lamp become opaque. The numerical values of the spectral intensities as obtained by this method are given in Table I, column 3. The lamp (a 110-volt, 16-candle-power, 4 watts per mean horizontal candle treated carbon filament) was operated at a fixed voltage corresponding, as determined by careful calibration, to 3.99 watts per mean horizontal candle. For the type of filament (oval anchored) this means 4.83 watts per mean spherical

* Transactions of Illuminating Engineering Society.

[1] Am. J. Sci., 3d series, Vol. XI, No. 236, 1890. Reprinted, Smithsonian Mis. Coll. No. 1258, 1901.

[1] For adjustment of apparatus, lamp, computations of radiation constants, etc., see Coblentz, Bulletin of Bu. of Stds., 4, p. 391; 5, p. 339.

candle, or 2.60 lumens per watt. The unit of candle-power is the new International Candle, 1.6 per cent lower than the unit as hitherto maintained at the Bureau of Standards. The wave length of maximum energy is $\lambda_{max} = 1.41\mu$; the compound radiation constant is $\alpha = 5.7$ which means that the emissivity of this treated filament is of the order of $(\alpha - 1 =)$ 4.7 the power of the absolute temperature. The observations were corrected for the variation in the reflecting power of the silvered mirrors of the spectrometer (data from Hagen and Rubens) on the assumption that the mirrors were perfectly new, which was not the case. Hence the observations are to some extent undercorrected, especially toward the violet.

The second method of measuring the distribution of energy (in the visible spectrum) was by means of a Rubens thermopile and a Fuess two-prism monochromatic illumination, in which the lenses had a focal length of only about 10 centimeters. This gave a more intense spectrum and at the same time a larger dispersion than obtained in the preceding apparatus. This combination also eliminated the question of the reflecting power of mirrors, which is difficult to determine in the visible spectrum. The numerical values are given in the second column of Table I. Complete energy curve was made by combining the two sets of observations reduced to equality at .6μ. The two curves so obtained agreed over their common range as closely as one would expect, considering the difficulties in obtaining such measurements.

Having already obtained the spectrophotometric relationship between the firefly and the glow lamp (by photographic means) and now knowing the distribution of energy of the glow lamp, we can at once calculate the distribution of energy in the spectrum of the firefly by multiplying the energy values of the glow lamp by the ratio $\frac{\text{firefly light}}{\text{glow lamp light}}$ at each wave length. In Table I, column 6 are given the energy values so derived at wave lengths corresponding either to points of density measurement or to points of intersection of density curves, as explained above.

The maximum of light emission is in the part of the spectrum to which the eye is most sensitive, the yellow green, at .57μ, and the extent of the spectrum is from .5μ to .67μ. Very much longer exposure might have shown greater length. It must be borne in mind that the measurements were made on extremely small areas, subject to errors from such local unevennesses in the plates as might occur[1] and therefore it is believed no particular significance is to be attached to the apparent slight concavity on the red side of the maximum or the twisted appearance of the maximum itself. The greater extension on the red side makes it similar in appearance to the complete radiator. Since the distribution of energy in the spectrum of the sun is approximately uniform through this region, the spectrum of the firefly as compared with sunlight has very closely the same character as the energy curve shown.

It is of interest to compare the luminous efficiency of the firefly with that of the carbon glow lamp and indirectly with that of other illuminants. If we know the relative visual intensity value of the different colors of the spectrum of a source of known energy distribution (the sensibility curve of the eye if the source gives a normal or equal energy spectrum) we can calculate the intensity value of any given energy distribution, and from it obtain the ratio of

$$\frac{\text{light (radiated energy} \times \text{visual sensibility)}}{\text{radiated energy}}$$

in common units. Koenig has determined the intensity distribution of a gas flame, and from the energy distribution of the flame as determined by Langley, Koenig's observations are expressible in terms of a spectrum of uniform energy distribution. These are given by Nutting[2] and the values for intensities above the Purkinje effect are here used.[3]. The procedure is to multiply the energy at each point by the fraction representing its visual intensity value. By luminous efficiency is meant

$$\frac{\text{light (radiated energy} \times \text{visual sensibility)}^4}{\text{radiated energy}}$$

For the glow lamp it is 0.43 per cent; for the firefly 96.5 per cent, these numbers representing the relative amounts of light (measured on a photometer) for equal amounts of radiated energy—a striking illustration of the wastefulness of artificial methods of light production. From the specific consumption of the tungsten lamp (1.6 w. p. s. c.) and the mercury arc (.55 w. p. s. c.) we obtain by comparison with the carbon filament that their luminous efficiencies are 1.3 per cent and 3.8 per cent. The most efficient artificial illuminant therefore has about four per cent of the luminous efficiency of the firefly.

We may express these comparisons in a different way if we make one assumption. Let us assume all the applied energy in the glow lamp to be used in producing radiation, none being lost by convection or conduction in the evacuated bulb base connections, and glass walls. The glow lamp has an efficiency of 4.83 watts per mean spherical candle, so we may say the firefly has an efficiency of 0.02 watt per candle, a quantity, because of our assumption, representing the upper limit of the specific consumption. This is to be compared with the tungsten lamp at 1.6 watts per candle, and the mercury arc at 0.55 watt per candle.

These figures are, however, to a certain extent misleading, for they give no weight to the question of color. The light of the firefly would not be acceptable as an illuminant for general purposes because of its green hue and small spectral extent. The color values of objects illuminated by it would be distorted to a greater extent than by the mercury arc. All hues would be submerged in a nearly uniform green. Considered from the point of view of the amount of white sensation as compared with the total luminous sensation[5] the firefly is very inefficient. This is of course a necessary consequence of the relationship between color and visual intensity, the most efficient light—disregarding the requirements of color—would be a single spectral line in the green. Its luminous efficiency on the basis used above would be 100 per cent, but it would be quite unsuitable for ordinary illumination. We may say, therefore, that the firefly has carried the striving for efficiency too far to be acceptable to human use, it has produced the most efficient light known, as far as amount of light for expenditure of energy is concerned, but it has produced it at the (inevitable) expense of range of color. The most efficient light for human use, taking into account both color and energy light relationship, would be a light similar to the firefly light in containing no radiation beyond the visible spectrum, but differing from it by being white. It should possess an energy distribution similar to that of a black body at about 5,000 deg. Centigrade in the visible spectrum, but falling to zero sharply beyond the limits of visibility. Such a light would be obtained by superposing the emissions of several substances similar to the light giving material of the firefly, but possessing maxima in other portions of the spectrum. Nature having developed a substance emitting in the green, it is not beyond possibility that similar substances may ultimately be found with different maxima of radiant energy. The luminous efficiency of a light of the character we are imagining may be calculated as we have calculated luminous efficiencies above. Taking the areas of the black body energy curve at 5,000 deg. C. between 0.4μ and 0.7μ (roughly the limits of the visible spectrum) and of the light curve given by the intensity values, and obtaining the $\frac{\text{light}}{\text{energy}}$ ratio, we obtain about 45 per cent for the luminous efficiency of the most efficient source radiating white light.[6] This is then the best we can hope to do by imitating the firefly, at the same time paying due regard to the limitations imposed by the necessity, for most purposes, of a fairly white color. Where color is of secondary importance it is not unreasonable to hope that we may some time approach the firefly efficiency.

The results reported in this paper may be summarized as follows: The spectrum of the firefly "Photinus Pyralis" has been photographed on plates sensitive to the whole visible spectrum. The spectrophotometric curve of the firefly, as compared with a carbon glow lamp, has been obtained by comparison of the photographic densities of the negatives of the firefly and of the glow lamp. The distribution of radiant energy in the carbon glow lamp has been determined, and by means of the spectrophotometric relationship the distribution of radiant energy of the firefly derived. The light is found to consist of an unsymmetrical structureless band in the yellow green of the spectrum, with a maximum at 0.57μ, and extending to 0.5μ and 0.67μ. The luminous efficiency of the firefly is calculated as 96.5 per cent as compared with 0.4 per cent for the carbon glow lamp, and about 4 per cent for the most efficient artificial illuminant. This value is obtained on the assumption that there is no infra-red radiation, other than "animal heat," as Langley concluded from his study of the Cuban variety.

Table I.—Emissivity of Carbon Glow Lamp.

	Glass Prism	Fluorite Prism.		Firefly Glow Lamp.	Firefly Energy Distribution.
λ			λ		
0.50	4.28		0.50	0	0
0.52	6.04		0.512	0.65	0.03
0.54	8.03		0.517	1.0	0.05
0.56	10.1		0.521	2.0	0.10
0.58	13.2		0.526	4.0	0.22
0.60	17.1	8.6	0.531	8.9	0.53
0.62	20.3		0.537	12.0	0.79
0.64	24.8		0.545	16.0	1.15
0.65		13.9	0.550	16.3	1.26
0.66	29.7		0.555	16.0	1.31
0.68	32.5		0.560	15.5	1.365
0.70	35.5	20.4	0.565	15.1	1.40
0.8	42.0	39.1	0.575	13.0	1.40
0.9		57.0	0.578	12.0	1.35
1.0		73.4	0.580	10.7	1.26
1.1		88.8	0.586	9.0	1.095
1.2		100.5	0.589	8.0	1.02
1.3		106.2	0.598	6.0	0.86
1.4		107.6	0.608	4.0	0.62
1.5		107.0	0.621	2.0	0.355
1.6		104.5	0.627	1.0	0.19
1.8		95.1	0.637	0.65	0.135
2.0		82.8	0.643	0.4	0.09
2.2		69.4	0.647	0.2[illegible]	0.06
2.4		56.0	0.652	0.20	0.05
2.6		42.5	0.659	0.13	0.035
2.8		30.6	0.665	0.06	0.015
3.0		23.5	0.670	0	0
3.5		12.5			
4.0		5.4			
4.5		0.12			

[1] A defect in the plate made it necessary to omit a density measurement at .57μ.

[2] Bulletin B. of S., 5, 2 261. The value unity is given to the maximum of intensity (.565μ).

[3] These intensity values are of course dependent on the accuracy of the gas flame energy values. These are much lower in the blue than for the glow lamp here used, which would suggest, since a gas flame is rather bluer than the 4 watt lamp, that a redetermination of the quantities in question by more sensitive means would change the intensity values used. The effect on the final values for luminous efficiency in this paper would not be altered appreciably by changes of the extent indicated by this apparent discrepancy.

[4] This mode of calculating luminous efficiency was first suggested, it is believed, by C. E. Guillaume (Soc. Int. Elect. Bull., 5, pp. 396-400, May, 1905). The numerical values are not to be compared with those obtained from the older method of calculating this quantity, in which the ratio of radiated energy between .38μ and .76μ to the total radiation is sought, a quantity having no direct relationship with efficiency as ordinarily understood in connection with artificial illuminants.

[5] H. E. Ives, Illuminating Engineer, Oct., 1909.

[6] On the assumption made above, that we may consider all the applied energy in the glow lamp to be given out as radiant energy, 45 per cent luminous efficiency means about 22 candles per watt. Absorption and convection probably reduce this by as much as fifteen per cent or to about 18 candles per watt.

Correspondence.

BAKELITE AND RESINIT.

To the Editor of SCIENTIFIC AMERICAN SUPPLEMENT:

In your issue of June 18th, 1910, No. 1798, page 399, appears a communication from Consul Thomas H. Norton of Chemnitz relating to a substance called resinit.

I beg to mention that *bakelite*, which I described one year ago before the American Chemical Society, answers his description of so-called resinit. Furthermore, my substance and its various industrial applications are protected by the following U. S. patents: 939,966, 941,605, 942,699, 942,700, 942,808, 942,809, 942,852, 949,671, 954,666, 957,137, and other patents are pending. Corresponding patents have been granted to me, or are pending, in all foreign countries of industrial importance.

For more than two years *bakelite* has been in successful use on a commercial scale for electrical insulators and various other technical purposes, and my communication on the synthesis, constitution, and uses of *bakelite* antedates by several months any published reference to resinit. My original paper (see Journal of Industrial and Engineering Chemistry, March number, 1909, page 149, published by the American Chemical Society) has been copied and translated in German by the Chemiker Zeitung (1909, No. 35) long before any communication on resinit was given to the public.

L. H. BAEKELAND.

Yonkers, N. Y.

An electric furnace for smelting zinc has been patented by H. W. Hixon. The furnace comprises a casing with a non-conducting refractory lining, and is provided with upper and lower electrodes, the latter constituting the interior bottom of the furnace. A central tube of refractory material projects through the bottom of the casing, and extends upward into the furnace. The tube is closed at its upper extremity, and is provided with passages which incline upward, and which establish communication between the interiors of the furnace and tube for the passage of zinc vapor through the tube to a condenser attached to its lower end. The walls of the portion of the tube near the lower electrode are made solid, in order to prevent the entrance of slag or other foreign material. An exit pipe is arranged in the top part of the furnace above the upper electrode, for withdrawing certain diluting gases. A hopper, consisting of two compartments, each provided with a conical closure, is arranged to project material into the furnace, each closure being operated independently of the other and being provided with locking and unlocking means, for preventing the escape of gases or vapors from the furnace or the entrance of air during the charging operation.

MINING COAL WITH EXPLOSIVES.*

SUGGESTIONS FOR THE MINER.

BY C. E. MUNROE AND CLARENCE HALL.

No UNIVERSAL rule can be made for blasting coal, for the local conditions, the character of the seam, and the method of working make it necessary to use different means in different mines and sometimes even in different parts of the same mine. The best method of blasting in any given mine or part of a mine is determined by practical experience and observation.

The placing of bore holes, as well as the size of

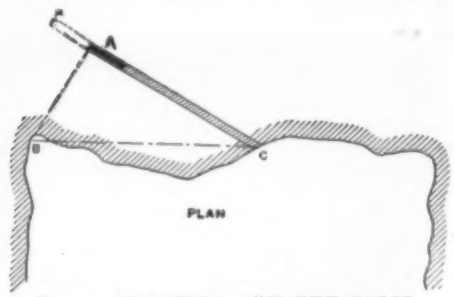


FIG. 1.—SHOOTING OFF THE SOLID.

the charge, is of vital importance. In placing them special attention and due consideration should be given to the bedding and cleavage planes in the seam; also to slate and bone parting, horsebacks, clay slips, and other local irregularities.

In this country, apart from the not widely used long-wall system and the pillar pulling or withdrawing, in both of which little or no explosive is used, there are two general methods of bringing down coal in entry driving or room work, namely, "shooting off the solid" and undercutting or shearing before shooting.

In the coal mines of the middle interior fields, where shooting off the solid is largely practised and where there are no marked faces or butts, the following method is used: A hole is bored or drilled in the face at or near the middle of the seam, and at such a slant as to make a small angle with the face. If an imaginary line (*AB* in Fig. 1) drawn

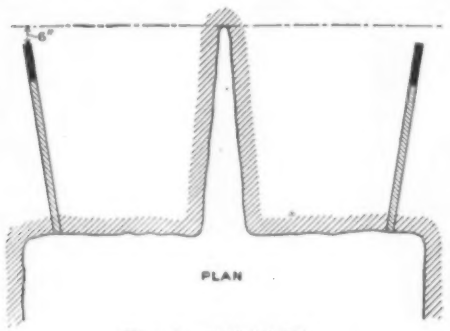


FIG. 2.—SHEARING.

from the back of the drill hole at right angles to the hole passes out of the open face, and if that distance is not too great, the hole is rated as "safe" by those who use the method. If, however, the hole extends beyond *A* to *X* (Fig. 1), the extended part is said to be "dead" and the hole is considered "unsafe." A hole is also considered "unsafe" if the angle *ACB* is greater than 35 deg. In the softer coals and where the joints or cleavage planes (cleat) are favorable a greater angle is used, but no drill hole, even under such favorable conditions, is bored at an angle greater than 45 deg.

In shooting off the solid only one face of the coal to be thrown off is exposed. It must be torn off along the line *AB* and *AC* (Fig. 1) and in addition must be forced out along the bedding planes at top and bottom. Where such bedding planes are smooth this is not difficult, but generally they are irregular, and a strong shearing force must be exerted parallel to the bedding planes, both at the top and bottom. This method to be effective requires a slow-acting explosive, and black blasting powder has been much used in the work.

A second hole and even a third one is sometimes drilled and charged before the first one is fired, and these are called "dependent" shots. The fuses are sometimes made of different lengths and lighted at the same time, with the expectation that the shots will go off in the proper order. Such practice is now generally held to be very wrong even in "solid shooting" districts. The second and third holes should not be drilled until after the first shot has been made, so that the location of each shot can be properly judged.

The size or weight of the charge in shooting off the solid varies much in different coals. In fact, it is extremely difficult, even in the same coal, to judge the amount correctly each time. If undercharged, the hole is likely to "blow out;" hence it follows that holes are almost invariably overcharged, and in some districts all sense of right proportion has been lost by the miners.

Aside from the dangers in the use of black powder, the uncertainties in proportioning the charge to the work are such that the method of shooting off the solid can not be approved as either precise or safe. Many of the great mine disasters of this country have undoubtedly started from misjudged or overcharged shots off the solid.

The other method of bringing down the coal, in which the explosive is assisted by undercutting or shearing beforehand and which was early used in this country, is now being readopted in most parts of the country. The object of undercutting or shearing is to expose two faces of the mass of the coal to be brought down, and, as coal generally tends to break along vertical planes, to permit the explosive to exert a wedging effect, rather than to shear or tear off the mass as it must in shooting off the solid.

There are two ways of applying this method—shearing and undercutting. Occasionally, where the coal is hard to shoot down, both shearing and undercutting are done, so that a less amount of explosive is needed; in fact, in some places none is required, as the coal can be wedged down.

Where the cutting is by hand and the top and bottom part "freely," shearing is the easier, and is usually employed in entry or narrow work. In some cases the shear or vertical cut is made on but one rib, but generally it is made in the center of the narrow face and the shot is so placed as to throw the coal toward the shear.

Where the coal is all alike in character and parts equally well at top and bottom the hole is started at or near the middle of the seam and drilled nearly parallel with the shearing, slanting a little upward to cross the bedding planes, and also to clear itself of dust as it is being drilled. The hole should never go deeper than the cutting, and it is better for it not to go as deep by at least 6 inches as the cutting. In Fig. 2 the back of the bore hole is shown as reaching the projected line of the rib, but in softer coals the backs of the bore holes are usually at least 6 inches from the projected line of the rib.

In districts where black powder is still used it is conceded that a shot hole of this character should never be charged with more than 2 pounds of black powder, and better with much less. It is difficult to make rules for an exact amount, because the proper amount differs with the length of the hole and cutting, the strength of the coal, and the way that it parts from top and bottom. However, the work should never be so laid out that it will require more than 2 pounds of black powder. If one of the permissible explosives is used, the charge should be, in general, only about one-half (by weight) what would be required if black powder were used; but no work should be so laid out—that is, no drill hole should be so located with reference to the shearing—as to require more than a pound and a half of the explosive.

Where the place is so wide that another hole is required near the first, when the first has done its work properly a similar situation is left for the second hole.

Where the coal is undercut, either by hand or machine, the purpose of the shot is to bring down the mass of coal by wedging from above. In such a place the greater part of the force of the explosive used in the first shot will go to shear off the coal on both sides of the shot, the expanding gases from the explosive working along the bedding plane at the line of the drill hole and the mass pivoting at the back of the undercutting. The stronger the bedding of the coal—that is, the less marked the vertical lines—the more difficult is this shearing, which then becomes a tearing, rending effect at the sides of the mass, so that the shape of the mass is somewhat conical, the top being at the line of the drill hole and the base at the undercutting. Under the circumstances the coal above the drill hole generally does not come down, but it is usually so scattered that it may be pulled down with a pick. Necessarily this first shot takes more explosive than later shots, but the amount should never be more than that already stated for the shearing method.

To help the first or "buster" shot, if the undercutting has been done by machine, it is advisable, and in some cases necessary, that the coal at the front edge of the undercutting be "snubbed" off either by

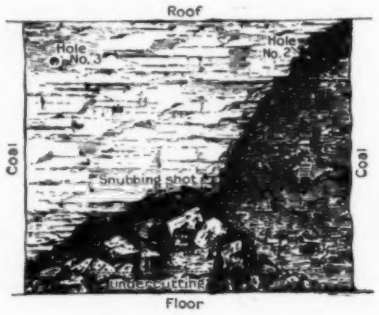


FIG. 3.—SNUBBING SHOT.

the pick or by a small "pop" or "snubbing" shot (Fig. 3). In narrow work, if the "buster" shot has done its work properly at one rib, the second shot is placed at the other rib. In wider work the "buster" shot is usually placed near the center of the room face and the second and third shots are placed on either side (Fig. 4). Each of these is so placed as to throw down a mass of coal which practically has three faces free—the front, the bottom, and one end. The chief work of the shot is to wedge off the rib end and push away from the back. Such a shot usually only requires from one-half to three-quarters of a pound of one of the permissible explosives. The work should be adjusted to these charges, so that if three shots besides the snubbing shot (if one is needed) are not enough, four or even five shots should be used. It is far safer to use a number of shots with a small amount of explosive in each than to use a few shots with a larger amount; and on the whole less explosive will be needed in all the small shots than in the few large shots.

The depth of the undercutting varies with the character of the coal and with the thickness of the seam, but in hand-pick work the depth is not commonly greater than the thickness of the seam. Where machines are used to undercut, the depth is from 6 to 7

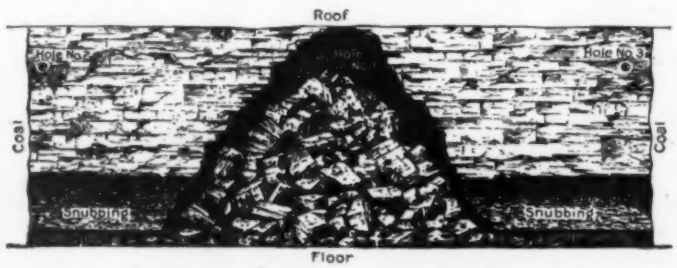


FIG. 4.—FIRST OR "BUSTER" SHOT.

feet, depending on the machine. With machines the cutting is usually done at the bottom of the seam; if the seam is thin (less than 3 feet) the cutting is done in the underlying clay, if there is any. Where the undercutting is done by hand pick, it is sometimes done in soft clay, but so far as the placing of the shots is concerned, the part above such an undercutting may be regarded as a thin seam, the coal below the cutting

* Abstracted from Bulletin 423 of U. S. Geological Survey.

being lifted afterward by "heaving" shots. Generally the cutting is in the bottom, and where it is so the shots are usually placed above the middle of the coal and sometimes near the top. Where the coal is undercut and black blasting powder is used, owing to the powder's slow wedging action the exact position of the shot is not of such special importance as it is where permissible explosives are used. As already explained, these are quicker in action than black blasting powder, and unless they dislodge the coal instantly their force is spent in shattering the coal near the drill hole. Therefore with permissible explosives the mouth and back of the drill hole should be nearer the roof and the hole should slant upward in order that the back of the drill hole may reach the top bedding plane (Fig. 5). The break will then be clean and a wedging action will be exerted along the top bedding plane.

In the use of permissible explosives, special care should be taken that each bore hole has the same width throughout and is wide enough to permit the cartridges to pass through it without too hard ramming. Too small a hole may cause the cartridge to stick, and nitroglycerin explosives or even black powder may be exploded by the friction of the tamping bar against the sides of the hole. Daily attention should be given to the drills that are used in drilling the bore holes, and the points of the bits when being sharpened should be made to a standard size.

Before a shot is fired in a working place "bug" dust and all other coal dust should be thoroughly wet and sent out of the working place. No cause of explosions has been more common than the presence of coal dust when shots are being fired. If the working place is naturally dry, it should be thoroughly sprinkled, and all the ribs, roof, and props within 40 feet of the shot washed down by hose before shots are fired.

Good results have been obtained in bituminous coal mines during the winter months by warming and moistening the air entering the mine by means of

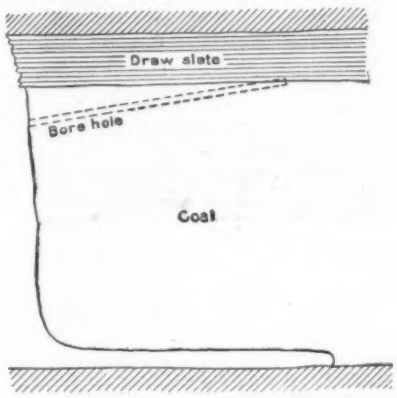


FIG. 5.—BORE HOLE FOR PERMISSIBLE EXPLOSIVES.

exhaust steam and spraying devices. In experiments made in December, 1908, at the Pittsburg testing station the outside air entering the gallery was warmed up to mine temperature and moistened by drawing it through humidifiers. It was found that if the air is kept at a relative humidity of 90 per cent and a temperature of 60 deg. F. for forty-eight hours, thus giving conditions like those of summer in a mine, the taking up of moisture by the dust and the blanketing effect of the moist air prevent a general ignition of the dust by a blown-out shot of black powder.

Since the new permissible explosives began to be used it has been found that more satisfactory results are obtained in mines where the loading and tamping of all shots are done by a few competent men known as "shot firers."

For the greatest safety the loading and firing of all shots should be done by shot firers after all other men have left the mine. The practice of having all shots loaded and fired by shot firers during the shift, which has lately been introduced in some of the mines of the Pittsburg district, is certainly a step in the right direction.

It is plain that the greatest safety and best work cannot be obtained when the miners are allowed to load and fire their shots, because the new permissible explosives must be properly handled to get the desired results. The shot firers should be selected from the more intelligent miners, and they should be thoroughly instructed in the great dangers that arise when the permissible explosives are used in any other manner than that specified by the Pittsburg testing station.

LOADING AND FIRING CHARGES OF EXPLOSIVES.

In blasting, any explosive gives the greatest disruptive effect when the charge most completely fills the bore hole from side to side. If the explosives are supplied in cartridge form this condition can often be obtained in the bore hole by splitting the wrapper, gently pushing a cartridge down into place in the bore hole with a tamping stick, gently squeezing it so that it spreads out to fill the entire width of the hole, and repeating this with each cartridge until the charge has all been put in. Finally, the detonator is placed in the last cartridge put in, and this cartridge is known as the primer. The primer is gently pushed down into place in firm contact with the remainder of the charge, and the hole is tamped (Fig. 6).

If the same weights of different explosives are of equal strength, the one that takes up least space—that is, the densest—will have the greatest effect in breaking coal or rock. Of two cartridges of equal size containing different explosives the heavier cartridge is said to have the greater density.

Black blasting powder to be used in blasting is made up into a cartridge by means of a paper wrapper

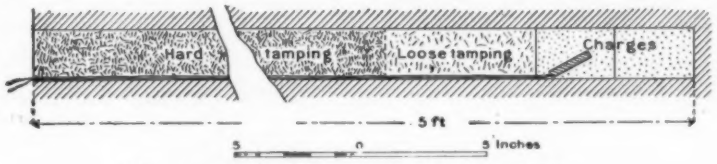


FIG. 6.—BORE HOLE READY FOR FIRING.

which has been formed about the handle of a pick. When this cartridge has been charged with powder, the electric igniter or fuse is placed and well fastened, and the cartridge should then be gently pushed down into the bore hole by means of a wooden tamping stick, which is safer than any metal bar. An iron tamping bar should never be used. When squibs are used, the cartridge of powder is placed in the bore hole and then the tamping is put in about a copper or brass needle rod until the hole is filled. Then the copper needle is withdrawn and the squib is put through the opening.

When only fuse is used, it should be long enough to reach beyond the mouth of the bore hole. The tamping should be packed in about the fuse quite to the mouth of the bore hole, and the fuse should be completely surrounded by tamping.

It is observed that in some mines the practice has been to use but a short length of fuse and to let the charge explode untamped, or simply secured by running the tamping bar into the hole. This is a very bad and dangerous practice and should be forbidden.

When detonators are used together with a fuse, the fuse should be cut off squarely at the end, gently inserted within the detonator until the powder core touches the detonating composition, and then, with the fuse held in the left hand, the detonator should be crimped onto the fuse with crimpers close to the open end of the cap, so as to make a perfectly tight and secure joint, care being taken in crimping that no pressure is brought to bear upon the detonating composition.

Two ways are in use of inserting the detonator and attached fuse into the stick of explosive that goes on top of the charge and is known as the primer. The more approved way is to open the top of the cartridge or stick of explosive by unfolding the paper at the end; then to make a hole by means of a wooden skewer or lead pencil in the top of the cartridge, deep enough to let the detonator be pushed into it up to the line of crimping; then to gather the end of the paper jacket or envelope together about the fuse, the whole being bound with twine, so as to fasten the detonator and fuse firmly in place.

Another way that is sometimes used is to insert the wooden skewer into the side near the upper end of the priming cartridge so as to make a slanting hole in the charge, deep enough to take the detonator up to the crimping mark, then to insert the detonator and bind it and the fuse close to the cartridge with twine.

The first way is perhaps more generally used, and it is better where the cartridge fits neatly into the bore hole. When the second way is used, the bore hole must be larger, as there should be some leeway between the cartridge and the side of the hole. In either way, when the primer, with the detonator and fuse, is put into the bore hole, extreme care should be taken that they do not come apart, for if there is any space between the cartridges in a charge, or particularly between the detonator and the explosive in the priming cartridge, the explosion may be prevented altogether, or may be a very poor one. Likewise, when a fuse and detonator are used in loading, care should be taken that the detonator is not completely buried in the explosive, for as the fuse burns and fire rushes from its end some of it may blow out over the top of the detonator and set fire to the explosive about it before the detonator is set off. This has been a common cause of inferior and dangerous explosions.

The same sort of trouble happens if coal dust or any other dirt is allowed to get between the cartridges in a charge, or between the priming cartridge and the charge. In loading, extreme care should be taken to make sure that the cartridges all touch one another closely.

When electric detonators are used they are fastened in the priming cartridge in ways like those described above for detonators used with fuse. When the electric detonator is inserted in a hole in the side of the priming cartridge, the practice has sometimes been to fasten it firmly by taking a half hitch around the priming cartridge with the legs of the detonator, the loading and tamping being then done as already described. This last means of attaching the electric detonator to the priming cartridge is not a good one, because the legs are likely to become kinked, and also because there is a chance that when the priming cartridge is pushed into place the insulation may be rubbed off from the legs and the wires may be short-circuited.

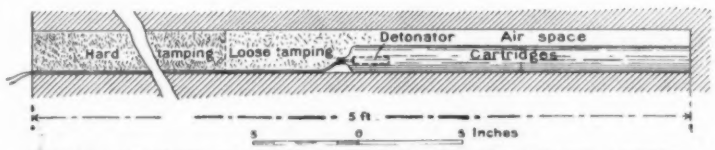


FIG. 7.—LOADED BORE HOLE SHOWING AIR SPACE ABOUT THE CHARGE.

Although it has been stated that with certain explosives, which are somewhat largely used, the cartridge case may be split and the charge rammed firmly into place, this is not the universal practice and should not be done with all the ammonium-nitrate class of explosives nor with some of the nitro-substitution explosives, for if they are tightly rammed in the bore hole, it is difficult or even almost impossible to explode them.

After the priming charge with its fuse and detonator or its electric detonator has been inserted in the bore hole, the hole should be tamped with clay or with other material that cannot burn. It should never be tamped with coal dust (either wet or dry) or with machine cuttings, known as "bug dust."

The tamping should be done by means of a wooden tamping stick. The pressure in tamping should be very gentle on the first tamping material put in, particularly if detonators are used in the primers, and great care should be taken at this time not to disturb the position of the detonator in the primer. Special care should be taken not to draw the detonator out from the primer or the fuse out from the detonator. When a fuse is used, care should also be taken not to rub the surface off it.

After the first 6 inches of the tamping material has been pressed down, greater force may be used in ramming the rest, because the firmer the tamping is the better is the work of the explosive and the less is the chance of a blown-out shot. The tamping should be continued quite up to the mouth of the bore hole. If fuse has been used, the upper side of it near the end may now be cut into on a slant, with a sharp knife, and the outer part bent away so as to form a notch in which the powder from the core gathers and to which the igniter is applied. This cutting prevents the loss of powder from the fuse and makes it easier to light.

The shattering effect of high explosives may be lessened in loading simply by pushing the cartridges into place without splitting or afterward squeezing them, so that an air space will be left about the cartridges in the bore hole, and then proceeding with the priming and tamping. This air space notably lessens the shattering effect of the explosive (Fig. 7).

Where it is desired to use black blasting powder, electric black-powder igniters, sometimes called electric safety fuses or squibs, are recommended for setting off shots. They are made in a general way like electric detonators, but gunpowder or other slow-burning composition is used in them instead of detonating composition. They are much safer for use in coal mines than ordinary squibs or fuse, both because they do not throw fire into the mine air and because they permit better tamping of the bore holes.

It sometimes happens that it is desired to fire a number of charges at the same instant. This is readily done with electric detonators by coupling them

up in series from hole to hole and firing by one discharge from the machine. This method endangers the roof and may cause falls. In mines other than coal mines it may be done by instantaneous fuse running from a central fuse to the several charges, but this practice is not a good one in coal mines, because the fuse may set fire to the dust or gas that is present.

In coal mines it is more commonly desired to fire one or more of the charges before the other charges, and this may be done in a single act of firing by the use of the delay-action electric detonators already described. An ordinary electric detonator is placed in the charge for the central breaking-down shot, and delay-action electric detonators are placed in the charges for the right and left rib shots. This method of firing has many advantages over the methods of firing successive shots by means of different lengths of running fuse, but neither method is recommended for use in gassy or dusty coal mines.

The safest way is to fire but one shot at a time, and to allow time enough between shots for the ventilating current to mix with and to render harmless the products of combustion from the previous shot and to carry off any coal dust that may have been thrown into the air by the shock of the previous shot. The interval of time that should elapse between shots differs with local conditions and the amount of ventilation, but in ordinary mining practice the interval should never be less than five minutes for shots made in the same working place.

In the making up of charges for loading bore holes and during the loading, extreme care should be taken that the explosives are not exposed to the flames from naked lamps or to sparks from the striking of metals upon each other or upon rocks, or from any source, since any of these may cause serious accidents.

As already suggested, the right size for a charge of explosive for blasting in a coal mine can be found better by practice than by theory. Several formulæ have been devised by which to determine the right charge beforehand, but unfortunately they have not given satisfactory results in practice. If the material or mass to be blasted were always alike throughout, and of equal hardness, theoretical rules could be made to apply, but such is not the fact. Differences in the resistance of the material to be blasted and in the rate of burning or detonation and the breaking force of the different explosives all affect the results of a blast.

Thus, for instance, in soft bituminous coal a permissible explosive containing only 20 per cent of nitroglycerin has been found to bring down more coal, and better coal, than one made under a similar formula but containing 25 per cent of nitroglycerin. A very quick explosive should not be used in bituminous coal mines where lump coal is sought. For instance, 40 per cent dynamite, which has been found by experiment at the Pittsburg testing station to have a rate of detonation of 4,688 meters (15,380 feet) per second is unsuitable for producing lump coal; but the permissible explosives that have rates of detonation between 1,866 and 3,617 meters (6,122 and 11,867 feet) per second are found to be well adapted for this work. Explosives that develop very high pressures are also unsuited for this work. Thus the 40 per cent dynamite referred to above has been found to produce a pressure of 8,308 kilograms per square centimeter (118,165 pounds per square inch), but the permissible explosives show pressures as low as 4,833 kilograms per square centimeter (68,740 pounds per square inch).

In deciding on the charge of a permissible explosive for use in a coal mine it is safe practice to use about one-half the weight of black blasting powder that would be needed to do the work; but no charge of permissible explosives should be more than 1½ pounds. As stated before, bore holes for permissible explosives are placed by a different rule for depth and direction than that which is followed when black powder is used. No permissible explosives nor any high explosive should ever be used in the same bore hole with black blasting powder.

The most obvious objections to overloading are that it crushes and wastes the coal, and that it throws fire and flame out into the air of the mine. Another objection is that the surplus force of the shot may so weaken the roof and surroundings as to cause falls, which may not occur, however, for some time after the shot has been fired.

Underloading, on the other hand, not only causes loss and waste, but it may so fissure the coal near by as to make it dangerous to fire another shot near the place. At the same time it may happen that the underloaded charge, though not strong enough to bring down the coal, may spring the bore hole, throw out the tamping, and give a blown-out shot; that is, a charge that is not heavy enough to make a blast may be heavy enough to act in a bore hole as it would in the barrel of a gun; and this may happen particularly if the tamping is not well secured and firm. Blown-out shots are especially to be feared in dusty and gassy mines, because it has been found that explosive mixtures, such as are present in such mines, are most sure to catch fire and burn most completely when a mass of flame, and more particularly a mass of glowing solid particles, is thrown into their midst. Investigation has shown that the larger number of the recent disasters in coal mines have been due to blown-out shots.

Premature explosions, misfires, and hang fires are most likely to happen when squibs and fuses are used to set off charges, owing to defects that may be in them from the first, or may be caused in the handling, carrying, or loading of them. Miners are especially warned in case of a hang fire to avoid returning to the breast until half an hour has passed. Hang fires rarely happen with electric detonators, but it is possible that they may happen more often with delay-action detonators.

Incomplete explosions may result from several causes. They may be due to failure to push in all the cartridges of a charge till they touch one another, thus leaving an air space between them, or else a mass of coal dust or dirt, which breaks the path of the detonation from cartridge to cartridge. They may be due to the pulling out, even but a little way, of the detonator from the primer or of the fuse from the detonator. In the use of nitrate of ammonia or nitro-substitution powders, incomplete explosions may be due to too tight packing and compressing in the bore hole. In any case, a partial explosion is a marked source of danger; first, because it may have the effects of an underloaded charge; second, because the unexploded part of the charge may burn and throw out flame and sparks into the mine, and also give out poisonous gases and fumes; third, because the unexploded part of the charge, if it is not burned up, may be brought down with the coal and give rise to an accident in the breaker, or, if it passes the breaker, to an accident in the transportation or the use of the coal. Whenever there is a partial explosion, if coal has been brought down, careful search should be made in the coal for the remainder of the charge.

In case of a misfire no attempt should be made to draw the charge, but a new bore hole should be placed at least two feet away from the first one and fired, and after the coal has been brought down it should be carefully looked over to find any unexploded material that may have come from the hole that misfired. When a hole charged with black blasting powder has misfired the tamping and charge may be withdrawn, drenching them with water while withdrawing them. After the hole has been dried out it may be reloaded.

NUMBERING THE STARS.*

THE ASTROGRAPHIC CHART AND CATALOGUE.

BY F. W. HENKEL, B.A., F.R.A.S.

IN all ages one's first impression as to the number of the stars visible has been that this is beyond counting, and, in fact, the saying "as the sands of the seashore and the stars of the sky for number" has become a sterotyped expression for absolute countlessness. Yet in reality the number visible to the unaided eye even of the keenest-sighted observer is strictly limited. In the whole of the heavens not more than two or three thousand are visible at one time, and by far the larger number of these are very faint, visible only by glimpses on clear moonless nights, so that we may fairly say that not more than about a thousand or so could be seen distinctly enough to be properly observed, and have their positions registered before the invention of the telescope. This is, in fact, the number (1005) contained in Tycho Brahe's star catalogue of 1580, the last and most exact list made in pre-telescopic days. On the invention of that instrument and its application to astronomy, exactly three centuries ago, the number of stars was enormously increased. Galileo's telescopes, not more powerful than a modern opera glass, showed at least 100,000 stars, and every increase in optical power has enlarged the number known to exist, so that for all we know their total number may be infinite, in the only sense in which we can attach a meaning to that term.

The great Lick telescope reveals not less than 100 millions of these objects, many of them as large or larger than our own Sun, some perhaps smaller, but others vastly greater in real dimensions, while the number visible in the Yerkes refractor and the giant reflectors of Lord Rosse and at Melbourne is greater still.

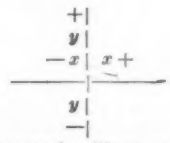
Catalogues or lists of the stars giving their positions and magnitudes from time to time have been formed, the earliest known one being that made by Hipparchus, who lived about 150 B.C. It is recorded that a new star having suddenly made its appearance in the sky, he was led to compile this list so that by comparison with it future generations might detect any changes either in position or in magnitude. His catalogue is not preserved in its original form, but was handed down to us by his successor, Ptolemy, the author of the famous *Almagest*, which for 1,500 years was accepted as the standard authority in astronomy. Another was made by the Persian astronomer Al Sufi in the tenth century, and five hundred years later appeared the catalogue of Ulugh Beigh, grandson of the famous Timur or Tamerlane, prepared from original observations. By comparison with Ptolemy's work he found that there were 27 stars recorded by Ptolemy which were too far south to be seen at Samarcand (where Ulugh Beigh's observatory was situated) and that eight others could not be found. As we have already mentioned, Tycho Brahe's catalogue was made in 1580, and a supplement containing a list of stars not visible in Northern latitudes was made by Halley (well known for his researches on the comet called by his name which has just been rediscovered), who made a journey to St. Helena in 1677 to observe them.

The number of modern catalogues of the stars is very considerable, almost every observatory having taken some part in preparing such. Catalogues of "precision," giving with the utmost accuracy the places of some hundreds of stars serving as "fundamental points" to which the positions of other stars, comets, planets, etc., may be referred, have been issued from time to time, those of our own National observatory being perhaps the most exact of all. Under the auspices of the Astronomische Gesellschaft, an international society having its headquarters in Germany, there has been prepared a catalogue containing the place of all stars down to the ninth magnitude (practically all those visible in a good opera glass or small hand telescope). A number of observations all over the world have co-operated in the production of this work, and it is now nearly complete. Not less than 100,000 stars in all will thus have their places very accurately determined, all nearly for the same epoch, and by comparison with future catalogues much valuable information as to star changes will be obtained. But this catalogue is also to serve another purpose, to which we now turn. The operations involved in forming a catalogue are necessarily lengthy and somewhat laborious. Every star has to be observed several times, its right ascension and declination (corresponding exactly with longitude and latitude of places on the earth's surface) determined by measurements with the transit circle, and the observed places *reduced* by the approximate corrections to a common epoch. About the middle of the nineteenth century, Argelander, as the result of vast labor on the part of himself and his assistants, published his famous Durchmusterung, giving the places of 324,000 stars of the Northern heavens, down to two deg. south of the Celestial Equator. This work was extended by Schönfeld to include stars further South down to twenty-two deg. from the equator, and the Uranometria Argentina and Cardoba Durchmusterung continue this down to the South Pole. The places of the stars are not given with the same precision as in the fundamental catalogues above referred to, but serve as means of identification when used for observations of comets and minor planets, etc. It was, however, the successful application of photography in taking pictures of the great comet of 1882 at the Cape of Good Hope observatory, that drew the attention of

* Knowledge and Scientific News.

astronomers to this new method for cataloguing the stars. Photographs of the comet showed not only that object, but also telescopic stars down to the tenth magnitude, distinctly impressed on the plate. From this success arose the Cape photographic Durchmusterung, and, indirectly, the Paris Astronomical Conference of 1887 and the Astrographic Catalogue of the Heavens. Sir David Gill and his assistants proceeded to photograph the Southern stars on a series of plates, and the positions of these were measured on glass reproductions by means of special measuring machines designed by himself. The photographs were mainly taken from 1887 to 1891, and the measurements of the positions and magnitude of about half a million stars were undertaken by Prof. Kapteyn, of Groningen, and completed in 1899. Though intended as an extension of Argelander's work, the photographic Durchmusterung is much fuller than the latter, and the star places are more exactly determined. Meanwhile, a yet greater undertaking had been inaugurated. Dr. Gill in 1886 proposed an International Conference to consider the question of making a great photographic survey of the whole sky, to include all stars visible down to the 14th magnitude, and this led to a meeting at Paris in April of the following year. Fifty-six delegates from seventeen different countries met together under the presidency of Admiral Mouchez, the director of the Paris observatory. It was resolved to photograph the whole sky upon glass plates about 10 inches square, each covering an era of four square degrees of the heavens. Two sets of plates were to be taken, one giving stars down to the 14th magnitude, another set, of much shorter exposure, giving all stars to the 11th magnitude. The number of the former stars was estimated at about 20 millions, that of the latter, from which a catalogue was to be prepared, about a million and a quarter. Eighteen observatories agreed to take part in the work, and all the plates were to be taken with similar telescopes having object glasses of apertures 13 inches and focal length 11 feet, on the model of the photographic refractor used by the brothers Henry, who had so successfully photographed the Pleiades group and detected new and hitherto unsuspected nebulosities surrounding the latter. The object glasses were to be specially corrected for the "actinic" rays, and a guiding telescope of somewhat smaller dimensions was attached to each instrument, so that the observer could watch the position of the star images during the operation and adjust the apparatus in the event of any shift or disturbance. It was originally intended to give each plate an hour's exposure, but improvements in the sensitiveness of the plates enabled that time to be considerably shortened. About 11,000 plates of this size are necessary to cover the whole sky, and since each star must appear at least on two plates, the whole number, allowing for overlaps, is about 22,000. Every plate contains a number of previously catalogued stars whose position is well determined, and so by comparison with these the position of all the other stars may be determined with accuracy. Owing to the great richness of stars near the Milky Way and the increased sensitiveness of the photographic plates, it seems probable that the original estimate of twenty million stars will be largely exceeded, and that double that number will be photographed when the work is complete. It was originally hoped that this would have been finished within five years or so from the time of starting, but delays, some unexpected and others not so, have arisen, and the period of twenty years sees it still unfinished. It is now, however, approaching completion, some backward observatories having fallen out and been replaced by others. Greenwich and Oxford have already published the greater part of their zones (Greenwich, Dec. 65 deg. N. to the pole; Oxford, Dec. 25 deg. to 31 deg. N.), and others are far advanced. The zone 40 deg. to 52 deg. S. allotted to the Cape observatory was started in 1893, and by the end of 1897 the required number of 1512 catalogue plates had been obtained and nearly half the chart plates, while in the following year it was decided to re-photograph the whole zone to bring the epoch at which the plates were taken nearer to that of the comparison stars. In 1900 Sir David Gill undertook to photograph the area within 2 deg. of the South Pole, originally allotted to the Melbourne observatory. Meanwhile the measurements of the plates, commenced in 1898 by the aid of a special machine designed by Sir David Gill, is now nearly completed, rectangular co-ordinates for 1,173 plates having been completed, reduced, and checked by the end of 1908. The work at Greenwich and Oxford is in an equally advanced state. Though it has been the idea of some astronomers that the place of every star in the sky shown in these plates should be given in the ordinary co-ordinates, Right Ascension, and Declination, corresponding, as we have said, exactly to longitude and latitude of positions on the earth's surface, yet it has been found practically much simpler and equally exact to give what are called the rectangular co-ordinates of the star instead. The method was invented by Professor Turner in this connection, and is a great simplification, though not less exact than the other.

The center of a plate is taken as the origin of co-ordinates, and two mutually perpendicular axes, the axis of x and the axis of y start from this point, the distance "x" being, as usual, measured horizontally right and left, "y" being the distance vertically upwards or downwards according to the ordinary convention—x, + to right, — to left; y, + upward, — downward.



Every plate is covered with a network or *rescau* of horizontal and vertical lines and the distance of each star in terms of *rescau* intervals, and its photographic magnitude, are determined. The plate is placed in a measuring machine, which is a framework, having a horizontal and vertical scale; also a reading microscope with scales or screws to measure fractions of a *rescau* interval. It has been found that, in this way, by taking the means of measures made when the plate is placed in one position, and then turned round through 180 deg.—i. e., reversed—the place of a star may be determined to an accuracy of less than 1/10 second of arc. At Helsingfors, the places of the stars are being all reduced to the ordinary co-ordinates of Right Ascension and Declination, but this heroic piece of work seems unnecessary in view of the results obtained elsewhere. The Astronomische Gesellschaft catalogue is all but completed, and it can be but rarely that the equatorial co-ordinates of any other stars will be wanted, the "rectangular" co-ordinates giving all required information when the Right Ascension and Declination of the plate center is known. By repeating the work later on it will be possible, by comparison of the newer photographs with those of the same region of the sky taken now, to collect a great mass of information as to changes of position and magnitude, "proper motions," variable stars, new stars that have appeared in the interval between the earlier and the later photographs, old stars that have disappeared, etc., and thus lay the foundation of a rational system of stellar astronomy. Already a few results of value have been obtained. Prof. Kapteyn, examining photographs of stars made at the Cape observatory, found the impression of a star of the 8th magnitude which was not contained in any catalogue. Examining different photographs it became evident that the star had been previously photographed, but always in a different position. Thus it was ascertained that this star had a more rapid "proper motion" (motion peculiar to the star after allowing for precision, nutation, etc.) than any other previously known, nearly 9 seconds of arc per annum, or one-fourth greater than that of the well-known 1830 Groombridge, sometimes called the "runaway star." Even so, this star would require nearly 150,000 years to make the circuit of the heavens moving at its present rate of angular progression. Since this motion is such that it could scarcely be detected by the unaided eye in the course of a lifetime, we may well use the expression the "fixed stars" knowing all the while that they are not fixed, but many of them are in motion which to our terrestrial notions is extremely rapid. Yet so vast is the distance of even the nearest of these objects from our system that many centuries must elapse before these motions produce much change in the relative positions of the stars, and the shape of the constellation figures. If it were possible for the early Chaldean astrologers of the plains of Shinar to revisit the scene of their labors, they would have no difficulty in recognizing the old familiar constellations. Possibly they might notice a slight change in the positions of Arcturus and perhaps of Sirius, but no others. Halley was the first to notice that since the days of Ptolemy, Arcturus has moved about a degree (twice the apparent diameter of the sun or moon) and Sirius about half this amount (2.1 sec. and 1.2 sec. annually).

Yet nothing can be more certain than this, that everywhere throughout the universe the stars are in motion. Our sun is in rapid motion toward a point not far from the direction of the bright star Vega; five of the seven stars of the Plough have a motion nearly the same in direction and amount; the well-known group of the Pleiades, almost as a whole, moves as a single mass with a common rate of about 7 sec. per century. Prof. Lewis Boss finds thirty-nine stars in Taurus having proper motions accurately directed to a single point of the celestial sphere, forming a great "globular cluster" about 15 deg. in diameter, having central condensation. In the course of revision of the astrographic work at Oxford new plates have been taken of certain regions of the sky where the number of stars on those already taken was less than was expected. These when measured are being compared with some of the earlier ones in the hope of detecting cases of proper motions, but so far the result has shown that large proper motions of faint stars are comparatively small. By means of the Astrographic Chart the materials for framing new and more reliable theories as to the nature of the connection between our sun and other stars, whether the Milky Way and the other stars visible form one system or two or more systems, or whether the whole is a "vast republic without any central authority," as the late Prof. Young said, are being collected on a scale and with a precision hitherto unattainable.

Three centuries ago most men considered our little earth to be the center of the universe, and it was long before this place was conceded to the sun. Then Sir William Herschel showed that our sun, too, is in motion, and only during the last century was it possible to say that vast though its dimensions are compared with all terrestrial standards, it is a mere "cadet" in the host of heaven. Mädler's supposition that Alcyone in the Pleiades is the central sun around which the others revolve, though probably erroneous so far as our own case is concerned, at least leads to the idea of mighty bodies compared with which our sun shrinks into insignificance.

If there be any relation between brightness and size, the stars Canopus, Rigel, and Deneb must be many thousands of times larger than our luminary, while Sirius, Aldebaran, and Arcturus are each of them suns of great magnitude.

With the completion of the Astrographic Chart and catalogue it will be possible to do thoroughly for the whole sky what has hitherto been done only for selected regions, and a record of the present state of the heavens will be left to all future generations.

A COMMERCIAL FUEL BRIQUETTING PLANT.

IN a bulletin of the American Institute of Mining Engineers, Mr. W. H. Blauvelt describes a briquette plant at Detroit, Mich., and gives the details of the operation, power consumption, labor, etc., of the plant as worked upon a practical scale of 9 to 10 tons of briquettes per hour. The briquettes made are small briquettes or "eggettes," weighing each about 2 ounces. The raw materials are coke-breeze, and dry non-caking coal from a neighboring coke-oven plant and mines. These are used in equal proportions by weight, mixed with 8 to 9 per cent of the binder, which is a hard coal-tar pitch. All these materials are ground together in a hammer-mill of the Jeffrey's or Williams' type. By grinding the coal, coke, and pitch in the one mill, the three materials are thoroughly mixed, and each particle of coal or coke receives a coating of the pitch powder. A rotary heater 21 feet in length by 40 inches diameter is employed for the first stage of the process; this is heated to a temperature of 80 deg. C. by means of superheated steam. The rotary-press used for the manufacture of the "eggettes" is of French manufacture and of the standard Belgian type. It consists of a heavy frame supporting two rolls, each of which carries in the middle a gear having a 7-inch face and a 2.5-inch pitch. On each side of the gear is a steel tire 5.25 inches wide by 2.5 inches thick is keyed and bolted on to the roll. The faces of these tires are cupped into recesses each about 2.25 inches long by 1.9 inch wide. The rolls are accurately registered, so that the cupping in the adjacent tires shall meet and produce an egg-shaped briquette. Each tire contains 207 cups. It is essential for the production of uniform briquettes that the mixed raw materials shall be uniform in temperature and composition, and that the quantity delivered between the rolls of the press shall be accurately controlled. A conveyor belt received the "eggettes" as they fall from the press, and gives them sufficient time to cool and harden before delivering them into the store. The power-consumption of the 10-ton plant, using electric motors for driving purposes, is:

	B.H.P.
Breeze conveyer to drier	1.50
Breeze drier and ventilating fan	2.85
Pulverizing mill	22.0
Elevating shaft and rotary mixer	10.0
Briquette press	25.0
Total	61.35

The steam consumption is 206 pounds steam per ton of briquettes, while the labor charges amount to 18.3 cents per ton—or $1.65 per hour—for the 10-ton plant. The installation of another press would double the output—while only adding three men to the seven required for the smaller plant—and the labor charges would then fall to 12.6 cents, as compared with 18.3 cents per ton of briquettes.

ENGINEERING NOTES.

The German imperial navy has recently received the addition to its active list of a destroyer, equipped with Zoelly turbines. According to The Engineer, this destroyer was built for a contract speed of 30 knots, and has two main turbines, each of 7,500 horse-power at 650 revolutions per minute. The boat has a displacement of about 650 tons, and its length is about 350 feet. The speed during the three hours' trial was nearly 32 knots, while the maximum speed attained in Eckenförder Bay, near Kiel, was 33 1/3 knots. The turbines, it is reported, ran perfectly during all the trials, viz., both in the workshops and after being fitted in the destroyer, and have not given rise to the least interruption. The trial readings gave the following results: Pressure at turbine, 14.85 atmospheres; vacuum, 89.95 per cent; revolutions, 643.9 per minute; slip, 23.4 per cent; average speed, 30.757 knots; steam consumption, 14.2 pounds. The exhaust from the auxiliary machines is not passed into the low-pressure stages of the turbine. Had this steam been so dealt with, the foregoing results in comparison with figures from other official trials would have been considerably modified.

A process for the direct production of iron or steel from iron ore has been patented in England by W. A. Hargreaves. The ore, preferably composed mainly of iron sesquioxide, is ground and screened to the necessary degree of fineness, the material passing through an 18-mesh sieve and retained by a 90-mesh sieve being employed. With an ore of greater fineness, the subsequent reaction might be too violent, but, should an extra heat be required, a certain proportion of the finer product may be mixed with the coarser ore. The ground ore, after thorough drying, is mixed with a sufficient quantity of powdered aluminium of about the same degree of fineness, and, in certain cases, as in casting or welding operations, with a certain amount of metallic iron or steel. As an example, the proportions: Ore, 62; aluminium, 20, and iron turnings, 18 per cent may be taken. The mixture having been placed in a crucible, the reaction is started in the ordinary manner by means of a fuse of powdered aluminium and barium peroxide. In order to obtain a steel of a given class, ferromanganese, spiegeleisen or iron containing the necessary amount of carbon may be added before or during the operation.

Bearing metals consist of a soft plastic matrix, usually composed mainly of tin or lead, in which harder crystals containing copper, tin, etc., are embedded. W. Guertler has endeavored to prepare cheaper products containing essentially lead as matrix and iron or iron alloys as the harder constituent. It is impossible to prepare such products by the usual fusion methods, as lead and iron are practically immiscible in the molten state. Successful results were, however, obtained by heating an intimate mixture of the powdered metals to 250 deg. to 300 deg. C. and stamping them in molds. The mixtures of powdered metals were prepared either by precipitating dilute lead solutions with excess of iron powder, or by grinding together iron powder and "lead-tree" crystals. Pig iron and spiegeleisen are especially suitable for the preparation of these stamped alloys, as they are cheap and can be easily pulverized in cement mills. Also, pure cementite may be used in place of iron, or chromium, tungsten, nickel, etc., may be added to the latter. The products are stated to have good mechanical properties. Mr. Guertler discusses the points of resemblance and difference between his stamped alloys, and the products prepared by Friedrich by kneading, whilst one or more of the constituents were in a pasty condition. He considers that both his products and those of Friedrich, so far as they are composed of metals, are to be regarded as true alloys.

ELECTRICAL NOTES.

In Rochester, N. Y., a good system of electric light and telephone wiring is in use, whereby unsightly pole lines on the streets are done away with. The system is applicable chiefly to the residential districts. The lines are placed in underground conduits in the streets, but instead of making connections with the houses directly from the underground conduits, a pole line is erected in the backyards of each block, and this pole line is connected to the conduits by an underground branch at each side street. This obviates the necessity of having a manhole in front of each house.

In commenting on the safety regulations with regard to the erection of electrical appliances, a European electrical engineer states that, while the subject is of extreme importance in the chemical industry no experimental work has been done, and it is only by deduction from experiments carried out in connection with the coal mining industry that any information is available. The very limited success which was obtained in preventing the explosion of gas from mines, when the sparking parts of the apparatus were immersed in oil, or when the motors, etc., were surrounded by wire-gauze, or more solid covers fitted with tortuous cooling outlets for the explosion gases, has led to the conclusion that really safe fittings have yet to be found and that security can only be obtained if all dynamos, motors, switches, resistances, etc., are placed absolutely outside of the danger zone.

A detailed and illustrated description of the Italian Metallurgical Society's works at Livorno, where about 10 tons of electrolytic copper is produced daily, is published in Elettricista. A current of 4,000 amps. at 100 volts, generated by 4 dynamos, driven by a steam engine of 600 horse-power, passes through 432 cells, consisting of lead-lined wooden boxes of about 1 m.³ capacity, each with nine copper anodes weighing about 120 kg., and ten copper kathodes. The electrolyte, which circulates through the cells by means of syphons, contains 130 gm. $CuSO_4$ and 120 gm. H_2SO_4 per liter, and is maintained at 50 deg. C. by steam coils. A certain number of cells have lead anodes, which serve to maintain the strength of the electrolyte constant, and have also a purifying action upon the copper, complex soluble salts of As and Bi being formed. The current density is about 1 amp./dm²., and the p.d. between the electrodes of each cell is about 0.35 to 0.45, that in those with the Pb anodes being 2 volts. The copper of the anodes has the percentage composition: Cu, 98.5; Fe, 0.07; Ag, 0.07, As, 0.20; Bi, 0.25; S, 0.25; Pb, 0.17; Sn and Sb, 0.10; Si, etc., 0.39; that deposited has a microcrystalline structure, a rose color, and contains 99.7-99.9 per cent Cu.

At the works of the Illinois Steel Company at Chicago a 15-ton Heroult electric steel furnace is in operation. It is worked in combination with an acid Bessemer converter, the object being to produce steel of open-hearth quality, or better, at less cost. At Worcester, Mass., a similar furnace is being used in combination with a basic open-hearth furnace, the object being to produce steel better than the best acid open-hearth steel though at a slightly greater cost. In the present instance the furnace is being used for the manufacture of steel for rails, axles, and wire. The process involves dephosphorization and desulphurization in the electric furnace. The opinion is expressed that the furnace is beyond the experimental stage, and is in continuous operation without difficulty. The energy used amounts to 194.5 B. T. U. per metric ton. If the charge is low in phosphorous the energy used is less. Analyses show that the results are uniform. The lining is kept in condition by throwing some shovels of burnt dolomite on the corroded portions of the hearth; the replacement of the roof is simple, and one of these lasted 129 heats, the cost being about 3 cents per ton treated; total cost of repairs is 6 cents per ton. Electrodes are consumed at the rate of 6 pounds per ton.

SCIENCE NOTES.

In this boasted "granary of the world," the records of forty years show that the average yield of wheat has increased one-half bushel per acre, while the average yield of corn has decreased two bushels per acre. Why should the average yield of corn in the United States be only 25 bushels per acre and the average yield in Illinois be only 35 bushels per acre, when the average yield upon the farm of the University of Illinois, on normal soil under practical, profitable and permanent scientific systems of farming, is 87 bushels per acre?

During the past dozen years the average acreage in corn and wheat in the United States has been increased by 30 per cent; but notwithstanding the enormous increased production thus made possible, we have been obliged to decrease our average exportation of corn and wheat from nearly one-fourth to only one-tenth of our total production; and at the same time the average price of these great basic food materials has increased by 52 per cent, corresponding approximately to the increase in the value of land in the great corn and wheat States, and to the consequent and inevitable general advance in the cost of living.

There was no need whatever that the cultivable farm lands of the eastern States should have been depleted. Lying at the door of our greatest markets, with the application of knowledge and with such encouragement as should have been given, those lands could easily have been preserved and even increased in fertility until their present value would have been not five dollars, but five hundred dollars an acre. Even now are the young men of the United States putting ninety million dollars a year into Canadian farms. Why? Because they were not taught in the schools that by investing those millions in the application of science to agriculture they can remain in the United States and secure greater profit and also save our soils from depletion; yes, make our partially depleted lands even more productive than they ever were, and at the same time provide the food that will soon be required to feed our own children.

The population of the United States has increased 100 per cent in thirty years, and without doubt will number more than 90 millions in 1910; but, notwithstanding the great areas of rich virgin lands brought under cultivation in the west and northwest, and notwithstanding the abandonment of great areas of depleted soil in the east and southeast, during the last forty years the average yield per acre of these two great grain crops has not even been maintained according to the twenty-year averages of the crop statistics of the federal government for the forty years from 1866 to 1905, as reported in the 1908 year book of the United States Department of Agriculture. Shorter periods might be selected which would give apparent indications of a different tendency, but less than twenty-year averages are not trustworthy for ascertaining the average yield per acre; and these two twenty-year averages show that the decrease in yield of corn has exceeded the slight increase in yield of wheat, much of which, it should be remembered, is now grown on land less than forty years under cultivation. And this statement holds not only for the entire United States, but also for the great north central grain belt, including Ohio, Kansas, North Dakota and the ten other states lying within that triangle.

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TABLE OF CONTENTS.

Page.

I. ASTRONOMY.—Numbering the Stars.—By F. W. Henkel, B.A., F.R.A.S. 46

II. CHEMISTRY.—Synthetic Rubber 34
The Crystalline Structure of Iron at High Temperatures 34
Bakelite and Resinit 43

III. ELECTRICITY.—Reversing Motors.—By J. S. McKee.—7 illustrations 37
The Electrification of Railways. II.—An Imperative Need for the Selection of a System for Universal Use.—By George Westinghouse 38
A New System of Wireless Telegraphy.—By the Paris Correspondent.—3 illustrations 41
Electrical Notes 48

IV. ENGINEERING.—The Great Triple Station of the Paris Subway at the Place De L'Opera.—By Lucien Fournier.—1 illustration 36
Turbines and Propellers 39
Engineering Notes 48
Universal Shear for Channels, Angles, and Plates.—2 illustrations 40

V. MINING AND METALLURGY.—Mining Coal with Explosives.—By C. E. Munroe and Clarence Hall.—7 illustrations 44

VI.—MISCELLANEOUS.—Science Notes 48

VII. PHYSICS.—Rays of Positive Electricity 40
The Light of the Firefly.—By Drs. H. E. Ives and W. W. Coblentz 42

VIII. TECHNOLOGY.—The India Rubber Industry, Past, Present and Future. II.—By Philip Schidrowitz 35
A Commercial Fuel Briquetting Plant 47

IX. ZOOLOGY.—Quilled Animals.—12 illustrations 33

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n yield
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For the
th cen-
Dakota
gle.

Page.
nkel,
..... 46
..... 34
tures 34
..... 43
ee.—
..... 37
ative
ersal
..... 38
Paris
..... 41
..... 48
Paris
ucien
..... 36
..... 39
..... 48
s.—2
..... 40
xplo-
l.—7
..... 44
..... 48
..... 40
W.
..... 42
Pres-
..... 35
..... 47
..... 33